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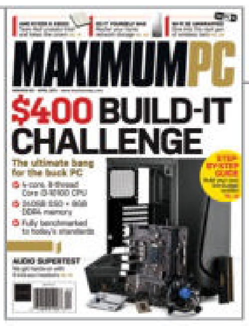

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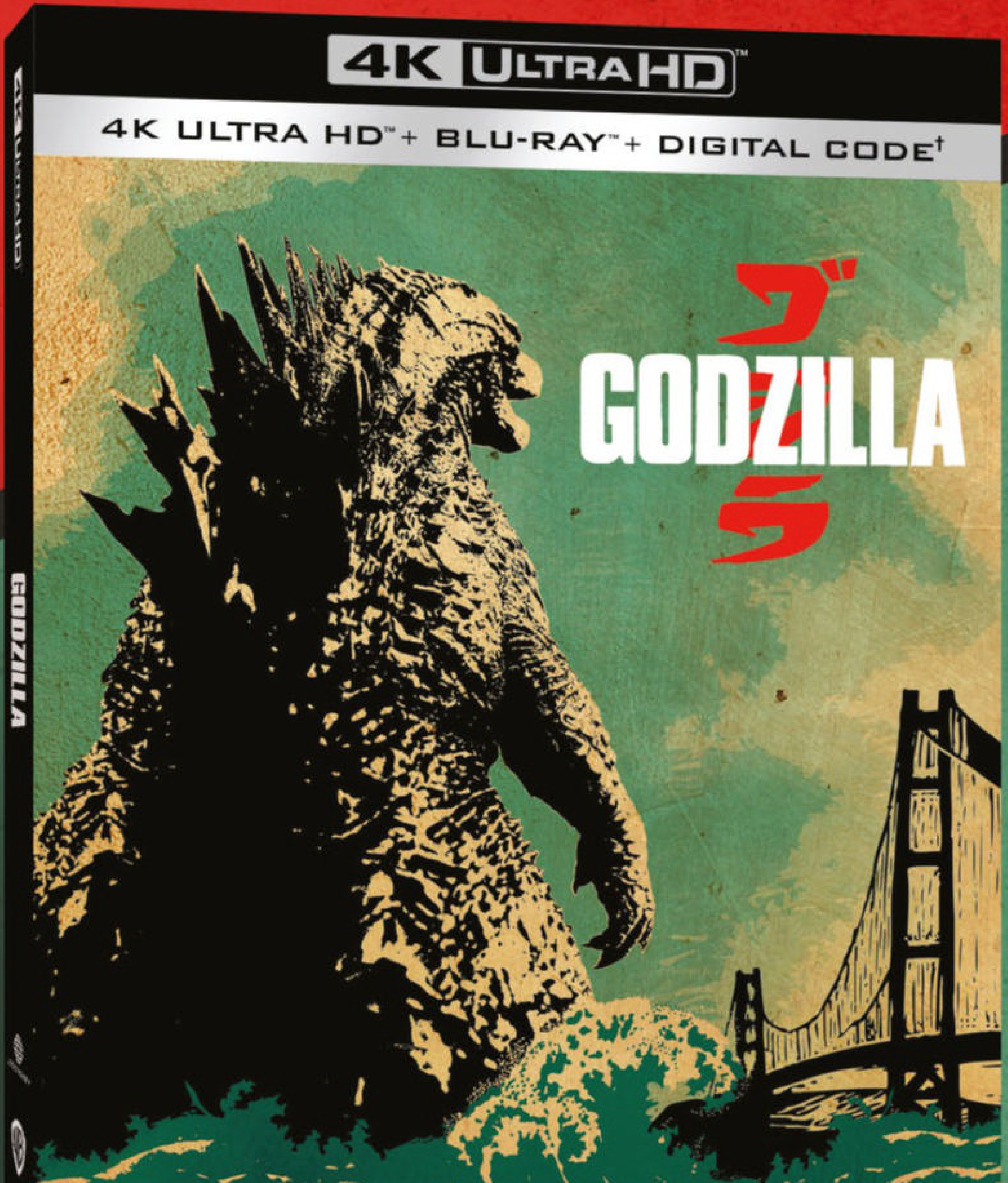
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BUDGET BUILDS

I DO LOVE a good challenge, and nothing is more difficult in this industry than building the ultimate budget PC. Bizarrely, the value of the dollar actually shifts depending on how much you have to spend. The less budget you have, the more important it is to allocate it correctly into the components that will give you the most performance. Things like flashy motherboards, cases, and memory just aren't important. On top of that there's an industry side-challenge to this as well. Namely, most manufacturers just don't want to showcase their more budget-oriented parts. That's what makes it so interesting from a journalistic perspective, because these are components that we don't see a lot of, and it's fascinating to analyze just how that performance from the flagship halo products filters its way down the product stack.

So this issue that's exactly what we did. The challenge was simple: grab the Intel Core i3-10100 that we used in our ultimate office PC, and then build a system around that that was as affordable and as quick as humanly possible. So that meant 8GB of DDR4, an SSD at a minimum, and stock componentry all round, to really find out just what you can achieve when on a super-tight budget in the middle of this hardware drought.

This issue we've got a ton more epic features too, including a guide on installing an OS on your own DIY NAS (including an introduction to Docker) from Nick Peers, a phenomenal headset group test and audio explainer from our new staffer Sam, and a perfectly short-yet-sweet analysis of the latest advancements in wireless technology, Wi-Fi 6E, from our favorite screen and chip guru, Jeremy Laird.

We're welcoming two new faces to this issue as well. I'm super excited to bring on Brittany Vincent, who joins us as a columnist from the realms of the digital, to give us her insight on industry trends (in a new section I'm fondly calling Trade Chat). She's worked across a ton of brands over the years, from *Tom's Hardware* to *Laptop Magazine*, *Mashable*, and even for Lucasfilm too. We're also saying hello to Kris Butterill who, aside from fighting fires as his day job, has also been a keen PC modder for a very long time and comes highly recommended. He's going to be bringing us some easy-to-follow how-to guides and tutorials, covering everything from modding your own GPU backplate (see PG 64), to 3D printing deep-dives and more.

On top of all that we've got an epic Photoshop tutorial, John Knight's retro lookback with his machine of the month, installing Chromebook OS on a Raspberry Pi, another antivirus head to head, *Hitman 3*, Blueprints, and reviews, including everything from AMD's monstrous Ryzen 9 5950X 16-core processor, to the latest Samsung 870 Evo 2.5-inch SSD, to an awesome modern-day review of IBM's prestigious Model-M keyboard, the pseudo-mechanical keyboard that started it all.

Honestly, this issue has been a pleasure to put together, and I truly do hope you enjoy it! As always stay safe out there, thanks for still supporting myself and the team, and I look forward to seeing you next time!

Zak Storey

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Stadia Shuts Game Developers Studio

No more in-house exclusives

IN AN UNEXPECTED move Google has closed its Stadia games developers studio, the internal team for exclusive Stadia games. From now on games will all be third-party titles. The move was particularly unexpected by the studio staff. Just five days before the closure an email from Stadia's vice president, Phil Harrison, had praised the developers on the "great progress" they had made. Google's announcement claims that Stadia's technology works at scale, but that creating top games from scratch is a "significant investment."

Google promises to continue "building on the proven technology of Stadia", but that it "will not be investing further in bringing exclusive content from our internal development team SG&E, beyond any near-term planned games." The huge multiplayer game worlds Google talked about at Stadia's launch won't be appearing any time soon, then.

Making top-flight games certainly isn't easy, or quick, although Google could afford the "considerable investment" required. It'll stick to licensing content, and developing the platform. A possible cited trigger by Harrison was Microsoft's acquisition of ZeniMax Media, which gives Microsoft access to a host of juicy game franchises such as *Elder Scrolls*, *Doom*, *Fallout*, *Quake*, and more. Exactly why this might push Google into quitting isn't clear, although we suspect Stadia will lose a raft of popular titles at some point soon. It hasn't taken long for the ramifications either—with no in-house developers, support is suffering. *Journey into the Savage Planet* has a few "issues," and since Google controls the code the developers can't fix it, and neither could Google for a over a fortnight. It might have fired a few too many developers?

Stadia is a game-streaming service, and received a good deal of attention when it launched in beta in 2018. It is, theoretically, capable of delivering games at 60fps, and at up to 4K. The launch soon bogged down though. The hardware didn't work as well as we hoped. The games were slow to appear, and interest soon faded among "serious" gamers. Despite talk of massive amounts of processing power to play the newest top titles, Stadia's audience is largely among more casual players, ones who don't want to invest in the kind of rig that can play a AAA title locally. It has managed to clock up around 2 million users, although many don't stick around for long.

Meanwhile, Stadia faces legal issues. The promise of 4K gaming was never met, and a class action lawsuit is in the works. Google had claimed that games such as *Destiny 2* and *Doom Eternal* could hit 4K. They can't. The suit is being made in the New York courts.

On the plus side we have promises of over 100 new games this year, including *Killer Queen Black*, *FIFA 21*, *Hellpoint*, and *Judgment*. There is a growing, and apparently happy, Stadia community. *Cyberpunk 2077* actually runs rather well on Stadia. Stadia also works nicely on smartphones. Stadia over-reached itself in its early days, but for many, it can be a good fit. The ability to run massively demanding games on a feeble laptop are impressive, although you will need a solid internet connection, and even then game freezes are still too common. Some really basic functions are also missing—it (unbelievably) doesn't even have a search function to help you find games.

The wheels may not have come off the Stadia project, but it is looking wobbly at the moment. Google has a history of walking away from high-profile projects when things get sticky. However, the long game is still to be played. If game streaming gets big, as with streaming television, Google will want to be in a position to grab a slice the cake. The game isn't over yet. **–CL**

PUSHBACK OVER ARM DEAL

PROPOSED ACQUISITION WILL SHAKE MARKET

NVIDIA'S PLANS to spend $40 billion buying ARM has caused waves in the x86 industry. If you want an x86 processor you go to Intel or AMD, or you use a company that employs an ARM design. These include Apple, Qualcomm, Samsung, Huawei, and other big players. Many more have ARM architectural licenses, or intellectual property licenses, including AMD and Intel, while others have huge racks of ARM servers, notably Amazon. ARM-based designs have been used in more devices than any other company—over 160 billion so far. Owning ARM would give Nvidia some serious leverage across the tech world. The obvious concern is that Nvidia will start saving the best ARM technology for itself, and start squeezing other users, many of which have no ready alternative. Previously ARM has been fairly generous with its licensing terms. Its present owner, the Japanese investment conglomerate SoftBank, has run ARM with a light touch. Google, Microsoft, and Qualcomm have requested that anti-trust officials look into the proposed deal. Nvidia now has to convince the regulators that it will use its extremely strong market position fairly, which should prove interesting. **–CL**

MYSTERIOUS MALWARE HITS MACS

Targeted M1 infection with no payload

SECURITY RESEARCHERS at Red Canary have uncovered a piece of malware, dubbed "Silver Sparrow," that has managed to sneak itself onto over 30,000 M1-powered Macs, and even some older Intel-powered ones. What the malware is designed to do remains a mystery, as the payload remains unidentified. It is not following the pattern of the usual adware infection. Silver Sparrow runs natively on M1 Macs, and uses JavaScript for execution. Once an hour it calls a server, presumably for further instructions. It hasn't, as yet, done anything malicious apart from bury itself into the macOS. However, it has managed to spread itself across 150 countries, and it's not clear yet how it managed this. Armed with a more directly destructive intent, this could have turned nasty. Apple has revoked the developer certificates that it needs to propagate, so we should see no more new infections. Given the lack of payload some have speculated that is was a test run for something more serious. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **PS5 TO GET PSVR2**
Next year Sony will release an improved VR system, tuned for the PS5.

✓ **SAMSUNG LONGEVITY**
Keeping Android phones current can be tough. Samsung has promised four years of security update support on 100 devices.

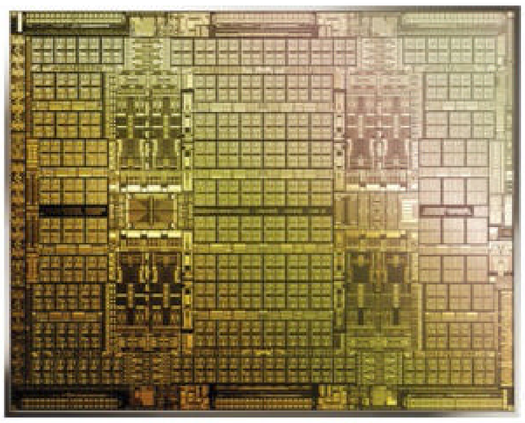
✓ **A CLASSIC RETURNS**
Iconic RPG *Diablo II* is to be remastered for consoles and the PC, now in 3D, and able to run 21:9 and in 4K.

TRAGEDIES

✗ **PORTLAND'S SMART-CITY PROJECT CANNED**
Disputes over privacy and data-sharing have scotched plans to turn Portland "smart."

✗ **AMD'S USB PROBLEM**
Some people are having problems with 500-series AMD motherboards triggered by high USB 4.0 usage, particularly VR.

✗ **RANSOMWARE ATTACK**
More troubles for CDPR as *Cyberpunk 2077*'s source code was swiped in a cyber attack.



MINING NIXED ON THE RTX 3060

Nvidia would rather you bought special mining cards instead

ANY HELP with the continuing graphics card drought has to be good news. Mining cryptocurrencies using GPUs hasn't helped. It can be highly profitable, and well-funded mining operations tend to hog the supplies of the best chips. Nvidia has decided to help by building a limiter into the driver of its new GeForce RTX 3060 card, which halves the hash rate for Etherium mining. Apparently this is the currency most suited to mining with its GPUs. It's a start, although why not limit mining across all cards, and all currencies? Nvidia has said that it currently has no plans to extend the idea. How secure the driver block proves remains to be seen.

Nvidia has a more practical reason for the move; it has just launched a range of cryptocurrency mining cards armed with dedicated mining GPUs, which it would like to sell to miners instead. Nvidia has dubbed these "CMPs" (cryptocurrency mining processors), not to be confused with CMPs (chip multiprocessors). Building these CMPs, according to Nvidia, won't affect the supply of GPUs, as the CMPs would not meet the specifications required for graphics cards. This would indicate that the chips are GPU with manufacturing errors that render them unsuitable for gaming cards. Turning these into CMPs is practical, although total GPU production is still fixed, and if the CMP cards prove profitable then Nvidia will be tempted to divert production.

Initially there will be four models: the 30HX, 40HX, 50HX, and 90HX. Etherium hash rates range from 26MH/s to 86MH/s (a GeForce RTX 3070 manages about 55MH/s). They have no display outputs, and run at reduced voltages for higher efficiency (mining is more about hash per watt). CMP cards will be available through the usual suspects (ASUS, MSI, Gigabyte, and others) by the summer. **–CL**

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INTEL'S FIRST GRAPHICS CARD

Basic, and original manufacturer only

AT LAST, we have Intel's first discrete graphics card, the Iris Xe, carrying the DG1 GPU. Well almost. Intel has announced its partnership with "two ecosystem partners, including ASUS," to bring its desktop GPU to specific pre-built systems (the other partner is Colorful, it's no secret). The technical specifications lists 80 execution units, a maximum clock of 1,500MHz, a memory bandwidth of 68GB/s over a 128-bit bus, and a maximum resolution of 7,680 x 4,320 over DisplayPort. Support includes DirectX 12.1, Vulcan, OpenGL 4.6, H.264, and H.265 hardware encode/decode.

This first step into the discreet graphics card market is a tentative one. The DG1 is basically a card version of the Iris Xe chip used in laptops, only slightly less powerful. Why start here? The idea is to sell older processors with poor integrated graphics to OEMs, and supply an economical graphics card to accompany it. These cards won't even work with newer Intel processors. Initial tests put the new card roughly comparable with a GeForce GTX 950 Ti. We will have to wait for the DG2 to see something that will worry the gaming market. This promises up to 512 execution units, if information gleaned from the latest Xe driver is to be believed.

The graphics card business has been a two-horse race for so long it's difficult to remember a time when the choice wasn't between an Nvidia or AMD-powered card. There used to be dozens—remember 3dfx, or SGI, or S3, or Real3D? All gone. Even if Intel never effectively competes with the big-ticket cards it doesn't matter. We get more cards, more stock, more choice.

However, we needn't be so pessimistic. Intel has been planning this for a long time, and the whole Xe family has been designed to be scalable right up to supercomputers. Raja Koduri, Intel's graphics chief, teased us with die shots of the Xe HPC (designed for datacenters) showing two GPUs, with multiple HBM modules. It could get fun. **–CL**

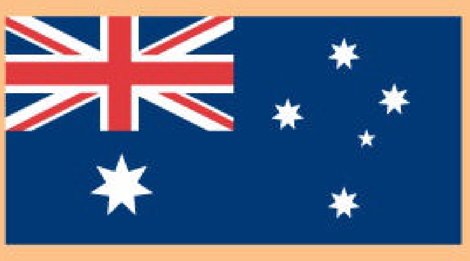
Samsung Puts a Processor Into Memory

SAMSUNG HAS DESIGNED a new iteration of Aquabolt (its high-end second-generation HBM2 modules). This one has a neat trick to it: integrated into the wafer is a processor to handle data transfers, which would otherwise be run by attached processors. The HBM-PIM (High Band Memory Processing In Memory) module uses some layers from its 3D stack to carry a dinky 300MHz programmable computing unit, or AI engine. The host (the processor) controls this using standard memory commands. The 16-bit PCU can perform FP16 ADD, MUL, MAC, and MAD calculations within the memory. Samsung says it "exploits bank-level parallelism to provide four times the processing bandwidth than an off-chip solution." Total processing power is quoted as 1.2TFLOPS

Samsung has some bold claims: a doubling of system performance, and a 70 percent decrease in power consumption between its HBM and HBM-PIM modules, with no software alteration. Giving over space to a processor does mean losing some capacity. The modules are 6GB, rather than the standard 8GB, effectively losing two layers of the eight-layer chip. The main market will initially be accelerating AI in fairly high-end applications. However, HBM is also found on the better graphics card, where bandwidth is king. Mixing memory and processor has been difficult because of the different manufacturing processes, and problems with heat dissipation. The first has been solved thanks to the 3D stack construction of HBM modules. The second problem may well account for the relatively modest clock speed of the processor part. **–CL**

WhatsApp Gets Serious About T&Cs

WhatsApp presented its users with a new set of terms and conditions in January, which drew such a backlash that it gave people an extra three months to accept them. The issue is that the new T&Cs are viewed as giving permission to siphon off more personal data to feed the Facebook data pile. WhatsApp says that people's personal data is still sacrosanct, but business accounts are not. Apparently it is all about data required for making payments. WhatsApp claims it still offers full end-to-end encryption. However, it isn't backing down—if you don't accept the new T&Cs your account will be listed as inactive, and ultimately deleted. WhatsApp was bought by Facebook in 2014 for $19 billion. It has a huge worldwide following with 2 billion registered users. The clumsy introduction of its T&Cs has cost it a few though, and illustrates how not to do it. **–CL**



Australia and Facebook are Friends Again

Facebook's spat with the Australian government is over. First Australia passed a law to make Facebook and Google pay for news content they hosted. Facebook and Google threatened to leave. Then Facebook followed through, blocking all users in Australia from viewing news content, including global news, and (mistakenly) some other government pages. After about a week of negotiations, news is back on Facebook. The law was amended so Facebook and Google are not subject to the new code, but do have to make undisclosed financial reparations to the news publishers. Who capitulated? It's not clear. Facebook's action drew considerable criticism, but the law was changed. The original law was certainly badly framed, and unworkable. Call it a draw. **–CL**

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Jarred Walton

TECH TALK

GDDR6X Hot Potato

GRAPHICS CARDS LIKE lots of memory bandwidth. Nvidia's RTX 20-series was the first to utilize GDDR6 memory, clocked at 14Gbps—a 40 percent increase over the GDDR5X in the GTX 1080 and 1080 Ti. With the RTX 3080 and 3090, Nvidia delivered the first GDDR6X solutions, clocked at 19Gbps and 19.5Gbps, respectively. What's interesting is that, while the 3080 features chips rated for 19Gbps operation (Micron D8BGW), the 3090 chips are rated for 21Gbps (Micron D8BGX), yet they're clocked at 19.5Gbps.

It turns out that even the 19Gbps chips can get quite toasty under certain workloads, like cryptocurrency mining. At launch, there wasn't a good way to check GDDR6X temperatures on the RTX 3080 and RTX 3090, but HWiNFO64 has added a new Memory Junction Temperature as of version 6.42 that works with those GPUs. While gaming tends to max out the memory temps at 100 C or less, Ethereum mining can easily hit 110 C—the maximum allowed before the GPUs throttle and fan speeds kick up to 100 percent. Nvidia's own Founders Edition cards are particularly noteworthy for letting the memory run hot.

Micron's spec sheets for the GDDR6X chips list an operating temp of 0–95 C, but it's unclear whether that's the same as the Memory Junction Temperature reported by HWiNFO64. It's also unclear whether 100-110 C junction temps are within spec or too hot. What we do know is that the backplates on most RTX 3080 and 3090 samples can get damn hot—as in, "Ouch, I think I burned my fingers" hot.

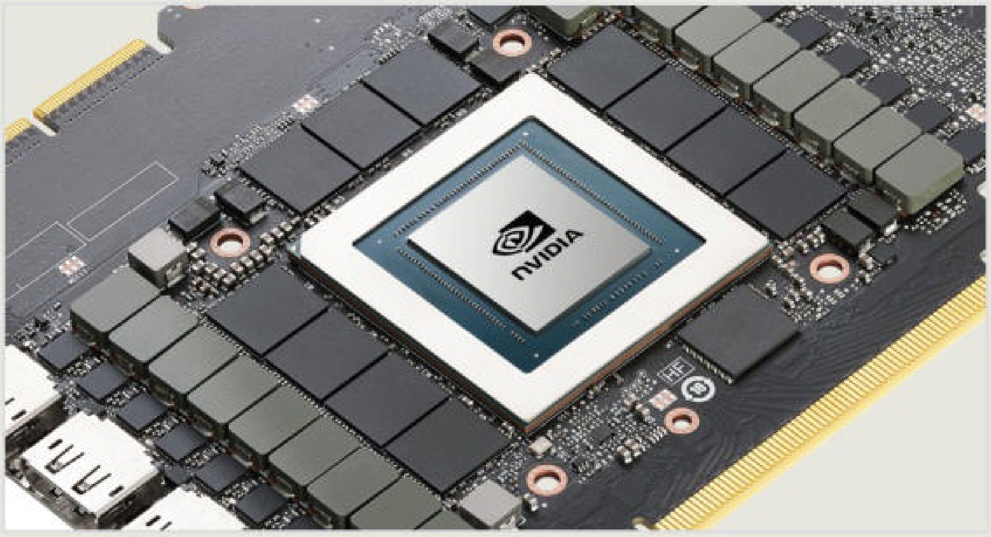
The good news is that it's not all RTX 3080/3090 cards that have problems. Some models appear to go to huge lengths to provide better memory cooling, with EVGA's RTX 3090 FTW3 the prime example. I've tested a few 3080 cards, however, and most will break 100 C given the right (or wrong, depending on your viewpoint) workload. And the "wrong" workload in this case means Ethereum mining.

We'll have more to say on the subject of mining next issue, but the Ethereum hashing algorithm was intentionally designed to be memory intensive, and it responds well to memory overclocking. If you already know this, and if you're already running mining software, do yourself a favor and make sure you're also looking at GDDR6X temps. If you have a card where the memory hits 110 C before throttling kicks in, we're very concerned about what that will mean in the coming months of use, and would suggest looking into ways to bring that down.

Increased fan speeds can help, or lowered power limits. Or it's possible to replace the thermal pads on the memory to improve cooling. We haven't tried that yet, but there are reports of a 10–20 C drop in GDDR6X temperatures after using better and thicker thermal pads.

Unlike memory temps, GPU thermals on the 3080 and 3090 tend to be less worrisome. Even with relatively low fan speeds, the models we've tested so far tend to stay below 70 C on the GPU. It's a shame that the memory cooling seems to have been an afterthought on many cards, including the Founders Editions. The RTX 3090 versions are particularly problematic, as they have GDDR6X on both sides of the PCB, but the rear plates don't provide active cooling on most models. If you plunk down over $1,500 for a graphics card, you'd think things like this wouldn't slip through the cracks.

> “Nvidia's own Founders Edition cards are particularly noteworthy for letting the memory run hot.



The RTX 3090 features 24 GDDR6X chips clocked at 19.5Gbps.

© NVIDIA

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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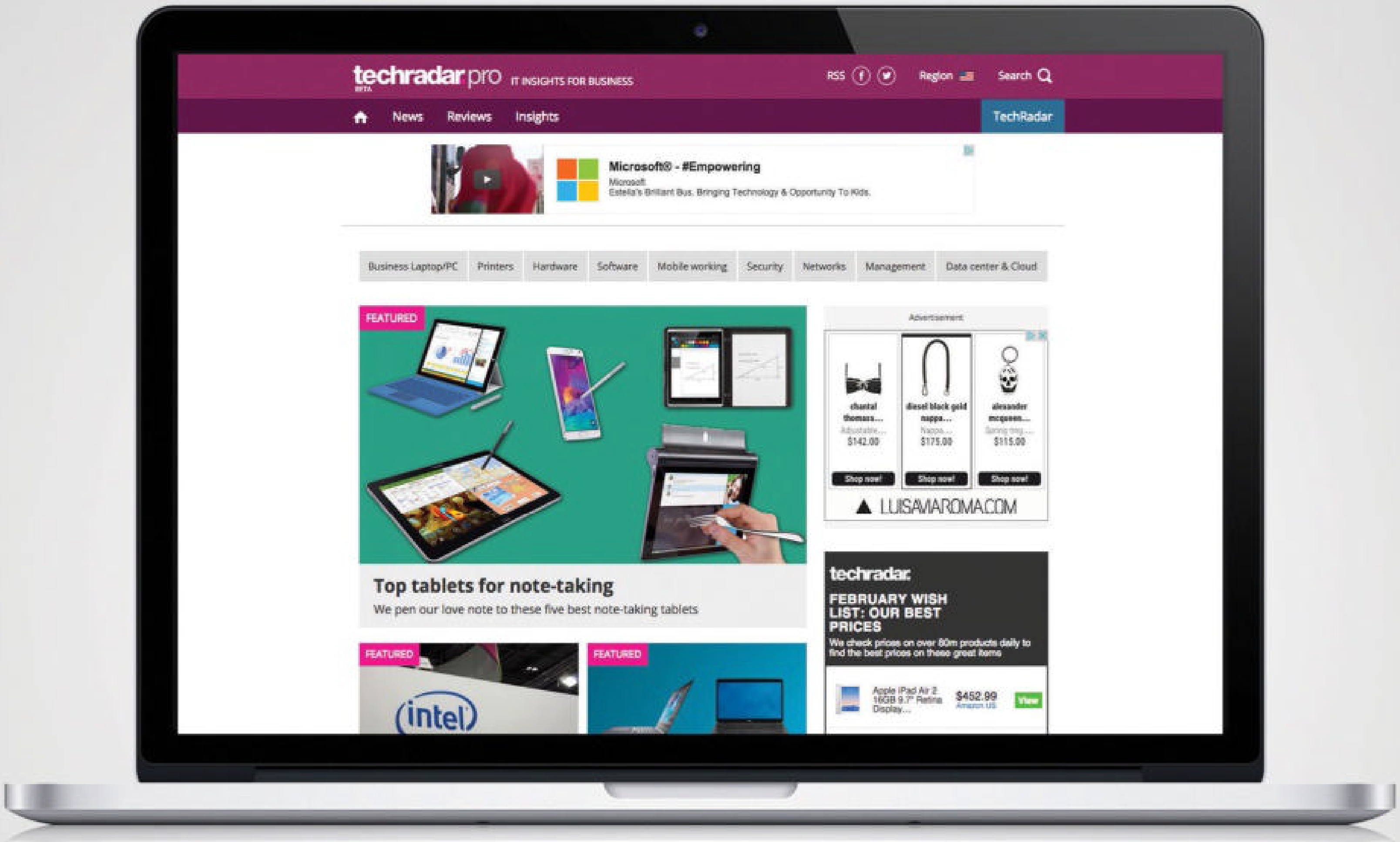
IT INSIGHTS FOR BUSINESS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Brittany Vincent

TRADE CHAT

Is PC Gaming Still "Worth It"?

AS A LIFELONG CONSOLE and PC gamer, I have nearly 25 years of experience with both landscapes. I cut my teeth on *Duck Hunt*, but I also breezed through *Duke Nukem 3D* and *Doom*. Both ecosystems have their own unique merits. For that reason, I'll never be able to proclaim a clear-cut winner in the never-ending console versus PC debate.

Still, I'm often asked if PC gaming is truly "worth it." With next-gen graphics card shortages, supply issues, and consoles that mimic PC performance, is the frustration worth the payoff? My response is an enthusiastic "Yes." Not only is PC gaming still worth it, but it's something everyone should experience.

It's a fact: PC performance will always be superior to what consoles can offer thanks to cutting-edge hardware and customization, but it's more accessible now than it ever has been. And if you love games, even if your consoles are as dear to you as mine are to me, you owe it to yourself to jump in.

Think about it in terms of iOS versus Android. Both have unique strengths, weaknesses, restrictions, and exclusive games. iOS is a closed-off ecosystem, while Android is customization-friendly. You can think of console and PC gaming in the same way.

Console gaming is simple and streamlined, while PC users have a wealth of opportunities stretched out before them. From adding controller support to a former mouse-and-keyboard title, to fleshing out meager accessibility options, if you have the know-how, you can do just about anything. It might not always work, but when it does, it's magical.

That freedom doesn't translate to the console world, but you can purchase a game and play it almost immediately with no tweaks. Consoles handle installation, updates, and any behind-the-scenes changes. But you're relegated to playing games how they come, save for sanctioned mods or DLC.

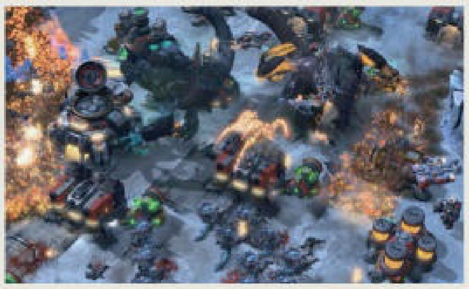
> Console gaming is simple and streamlined, while PC users have a wealth of opportunities

PC gamers have a dizzying amount of mods available. Where else could you add Thomas the Tank Engine to *Resident Evil 2* as Mr. X? What console lets you upscale a classic title, or enjoy an MMO that's had its servers yanked offline?

There's also an expansive catalogue of classic titles, indies, former console exclusives, and AAA games available from a litany of platforms like Steam, the Epic Games Store, GOG, and Humble Bundle. Console players are relegated to physical purchases or the stores on each platform, many of which are lacking classic titles.

Then there's the elephant in the room. PC gaming is cast in a negative light due to its upfront costs. People compare "thousands" of component and peripheral fees to a few hundred bucks for a new console.

Here's the thing. PC gaming is more affordable than ever. While you typically can't build a formidable gaming desktop for under $400, you can cobble together a build that's on par with or better than a console for a few hundred more. It can be tempting, of course, to shell out for the latest and greatest GPUs and equipment, but it's not necessary. You don't need to build it yourself, either, but if you want to, countless online tutorials are here today, whereas a couple of decades ago they were nowhere near as plentiful.



***StarCraft II* is a PC exclusive.**

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In the end, it doesn't make a difference whether you're tracking down a GeForce RTX 3080 or a PlayStation 5 if you can't purchase either. At some point, you have to decide: go for cheaper, more readily available components and run the games you're dying to try on console, or wait to nail down a system on which said titles aren't yet available?

There are a dozen reasons to build or purchase a PC expressly for the purpose of enjoying the greatest games, just as there are for consoles. But in the end, if you want the best performance, highest fidelity, and widest variety of games available, you need to dip your toes into the world of PC gaming.

Brittany has been writing about gaming, tech, anime, and more for 14 years. Follow her on Twitter: @MolotovCupcake.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Foolproof Backups
> Online Ticket Tips
> Possible Laptop Hack

Backup and Reinstall

I would like to know how to make a backup of my entire computer. Also, I would like to download a brand-new install of Windows 10 64-bit. My version was previously one downloaded by an employee of Office Depot. Unfortunately, I don't have a copy—this could be a problem if my computer crashes, as I'll have nothing to show for it. Please advise.

–Jerry Yaron

THE DOCTOR RESPONDS: Go to www.macrium.com/reflect-free.aspx to download and install Macrium Reflect Free. Once installed, open Macrium, and, assuming that Windows, your apps and all your personal files are on a single drive, choose "Create an image of the partition(s) required to backup and restore Windows," then follow the prompts to create a recurring backup to your hard drive. Choose the "Differential Backup Set" template for a sensible backup regime, involving daily "differential" backups to keep the backup size down. Choose "Other Tasks → Create Rescue Media" to create emergency bootable media on CD or USB flash drive so you can recover your backup if Windows becomes unbootable.

You can create your own Windows installation media by downloading the Media Creation Tool from www.microsoft.com/software-download/windows10—use this to create a bootable USB flash drive, which you'll be able to use to reinstall Windows from scratch on your computer, should the need arise. The key thing is determining what kind of Windows 10 license is on the computer—if you log into Windows 10 using your Microsoft account username and password, then it's a digital license. What this means is that you can skip the prompt for a product key during installation, and Windows 10 will automatically reactivate after you've set things up from scratch.

Online Ticket Tips

I frequently book tickets to events that tend to sell out quite quickly—sometimes in a matter of seconds. The usual process is to press Enter and then get an option with available tickets, but when I select them and hit Enter again, the ticket is frequently no longer available, and I have to repeat the process—either getting inferior tickets or sometimes nothing at all.

HP's S700 Pro is an affordable and long-lasting SATA SSD.

Therefore, I'm trying to set up a dedicated internet approach to maximize my responsiveness in these situations. My computer is an older PC with an Intel i7 processor and connected to my cable internet connection via a Gigabit Ethernet cable. OS is Windows 10 Pro and is up to date.

I currently use Firefox, which is perfectly satisfactory for day-to-day browsing. I have many bookmarks and it's probably quite full up with browsing history, and so on. I've been reading that there are several settings that can be changed to increase Firefox's "speed" but I'm reluctant to mess around too much in case I inadvertently worsen its overall performance.

I also recently read that Vivaldi would be a faster browser so I may install Vivaldi for this one function – then it would not be saddled with the inevitable accumulation of history and so on. I'd appreciate any guidance you can provide – for example, would it help to shut down unneeded programs while trying to book a ticket? Also, any settings I might change in Firefox or Vivaldi if that seems the best route?

–Gord MacDonald

THE DOCTOR RESPONDS: Perhaps the issue here is that you're reduced to taking part in the general melee that occurs whenever tickets go on sale to the wider public. If an event is particularly popular, you might want to consider a different approach: look for presale offers, such as joining a fan club or signing up for a specific credit card when an event is due to go on sale. Not only do you get the jump on the great unwashed, you'll unlock better seats in the process. Also, see if you can source the tickets elsewhere—try the venue directly, for example.

Otherwise, you might want to consider whether your computer is actually the best platform to buy those tickets on. Ticketmaster's mobile app is considered faster and more efficient than sitting on your web browser, for example.

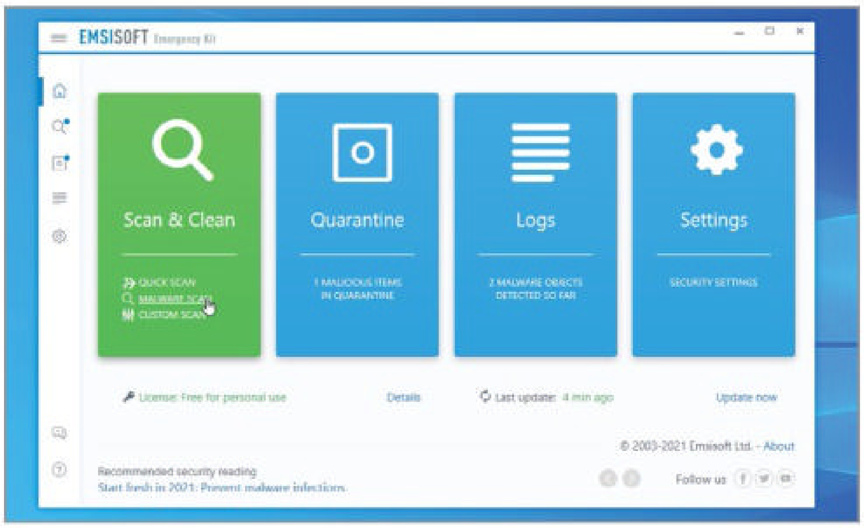
If you're going to stick with your PC, though, there are

↘ submit your questions to: doctor@maximumpc.com some other considerations: is your internet connection fast and stable enough? Once you've selected your tickets you should be able to complete the checkout process without losing them or your place in the queue, but if your connection drops or is too slow, then you're back to square one. The quality of your connection is determined by its signal levels—see http://bit.ly/MPCspeedguide for a generic guide, using your router's administration tool (accessible by typing its IP address into your browser) to measure your current settings. If you see problems, talk to your ISP.

The Doc also likes the idea of trying a different browser, but not necessarily for the reason you're thinking. He's wondering if ticket websites are optimized for Chromium-based browsers over Firefox's Gecko engine, for the simple reason that they're far more popular: Chromium browsers cover Vivaldi, Edge, Opera, and of course Google Chrome. With this in mind, you won't lose out by trying it.

CAPTCHA tests are another bane of anyone attempting to jump through ticket sales, so if you find yourself losing valuable time to these checks, try a browser plugin that can safely disable them—many like AntiCaptcha (https://anti-captcha.com) charge a small sum ($1 will cover 2,000 images) but can circumvent most CAPTCHA tests pretty quickly. If you want to try a free service, then Buster (https://github.com/dessant/buster) is one to try. Test this on an event that's less likely to sell out to see whether it has any positive effect on your ticket-purchasing process.

If all else fails, try Googling "Ticketmaster tips" or whichever ticket website you're trying to get tickets from—you'll find plenty of tips and tricks that may improve your chances going forward.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QUICK SCAN
MALWARE SCAN
CUSTOM SCAN
Quarantine
1 MALICIOUS ITEMS IN QUARANTINE
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Emsisoft utilizes two antivirus engines to scan your machine.

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Gateway All-in-One Upgrades

In this time of low supply and high cost of PCs, I am trying to get by with a Gateway ZX6971-UB20P. I would like to upgrade some components, to make it more usable. One thing I know about this device is none of the components are easily accessible like a laptop. Based on my experience with opening laptops, I will take it to a shop to install the new parts.

My issue is getting the right parts ahead of time. With Gateway being out of business, and their support site very small, it is hard to know what I need. I want to add more RAM, yet some resellers say I can use two sticks of 4GB DDR3 RAM while others state 2 x 8GB. I also want to swap out the HDD for an SSD. I'm sure it only supports 2.5-inch drives, but not sure what brackets will be needed. Also, one of the fans is very noisy, and therefore likely at the end of its life, but again, not sure what sizes to get. Any ideas where I can find all this information?

–Al Howarth

THE DOCTOR RESPONDS: We saw your query on Reddit, which elicited just the one response—one that directed you to a YouTube clip that appears to cover disassembling a different model. However, searching YouTube for "ZX6971" reveals numerous disassembly videos that will probably reinforce your decision to get someone else to fit the upgrades for you.

The videos made it difficult to work out if the existing drive is 2.5-inch or 3.5-inch, but that doesn't matter—the SSD can either be screwed into the existing metal cage, or simply secured to the chassis using double-sided tape. Your PC's SATA-II interface limits you to 3GB/s transfer speeds, so don't break the bank looking for a performance-driven SSD, you'll still benefit from much faster transfer speeds.

In terms of upgrading the RAM, we took a trip to Crucial (www.crucial.com) where we were able to select your exact model from the memory-finder tool. This recommends no more than 8GB in total (2x4GB). Sadly, all available modules were listed as out of stock; however, it reveals you're looking for DDR3L-1600 SODIMM laptop memory (specifically PC3-12800, CL=11, Unbuffered, NON-ECC, DDR3-1600, 1.35V) and can redirect you to www.newegg.com: you'll find that a 4GB module currently costs $20 (so $40 in total for an 8GB upgrade).

Finally, the Doc had to dig deep to track down the replacement fan you'll need. Go hunting for the following part numbers: BUB0812DD-BD88 or 1323-00DY000—the fan fits several models, including Acer All-in-One machines as well as Gateway. Expect to pay around $20 from newegg.com for the fan.

Possible Laptop Hack

Our laptop has been hacked: The Windows 10 admin password has been changed, as have two Excel spreadsheet passwords. Now the only way I can log into the laptop as an admin is using the fingerprint scanner.

–Larry

THE DOCTOR RESPONDS: Larry also followed up with another email saying that his laptop takes 8-15 minutes to fully boot, and that the hard drive runs continuously. All of this is probably related, which means we'd recommend you disconnect it from the internet, and then take steps to run full security scans with both your existing security software, and then using a series of third-party tools, which you should download on another, clean computer before transferring across to your infected laptop.

Two tools you can run directly from Windows as portable scan-and-remove apps are Emsisoft Emergency Kit (get it from www.emsisoft.com/en/software/eek/) and VIPRE Rescue (www.vipreantivirus.com/vipre-rescue-virus-removal-tool.aspx) if EEK doesn't work. Failing that, try a free bootable rescue disc such as Kaspersky Rescue Disk 18 (https://support.kaspersky.com/krd18). If nothing is found, and you can still install software on your infected laptop, download the free version of Malwarebytes Anti-Malware (www.malwarebytes.com) on your clean machine, then transfer it across and install it to run a deeper scan for other potential infections.

Assuming it finds and removes any infections, you're left with the clean-up process. If you log on to Windows using a Microsoft Account, then visit https://account.microsoft.com to verify that the password has been changed, and then take steps to recover your account (go to https://account.live.com/password/reset if necessary).

For your Excel passwords, you'll need a tool like Excel Password Recovery (http://bit.ly/MPCexcelrecovery)—use the free version to determine if it can guess the password, then purchase a single personal license for $39.95 to unlock the files for use again.

HEADPHONE HEAD TO HEAD

Discover the best sound for your needs

SOUND is just as important as vision. It is everywhere around you, and can take your mind away to wherever you want. Sometimes you can't always put your finger on why you like a sound, you just like it. That's why judging audio quality is a tough review process to trust. Everyone's ears are different, and we pick up every sound in our own way. Every click, cry, sigh, laugh, shout, car, plane, melody—you name it, we are all going to hear it a little differently to the next person.

Over the last half a century, audio listening has become a staple of day-to-day life. Whether that is starting your day by waking up to your favorite 1980s thrash metal song, walking the dog to some Cher (we know you people are out there), or you are more on the commercial side, with conference calls from nine to five—audio listening has pushed its way into everyone's homes. –SAM LEWIS

THE JOURNEY OF PERSONAL AUDIO LISTENING

THE MUSIC WORLD as it stands is a strange one. As a whole we no longer own music. Streaming is the done thing, and it has fundamentally changed the way we consume music. Meanwhile, everything is going wireless—less is more, cables seem old-fashioned, and the chances of you seeing someone walking around looking like a special agent with buds in their ears is increasing. However, can streaming bring the music industry back up to track where it was in its heyday? Potentially, but first, we must look at how we got here.

REVOLUTIONARY SOUND

1877, remember it? Well, it was the start of it all, with the invention of the cylinder phonograph, the first real commercial sound reproducer. It enabled people to listen to music from the comfort of their own homes. In essence, it was extremely revolutionary and has changed the way we listen to music ever since. It worked mechanically using a needle that traced the groove on the cylinder, vibrating the needle back and forth. These vibrations hit the diaphragm, creating sound waves that you can hear out of a large horn, creating the music.

A decade later saw the introduction of Emile Berliner's gramophone. It worked in a similar manner, but instead of a cylinder, it utilized discs, technically making it the first "record player." Berliner's gramophone took what made the phonograph revolutionary and improved it, and was itself developed over the following decades. Recording traced a line along a rotating zinc disc that was coated in wax and oil. Then, the disc had to be electroplated, creating a negative disc with grooves that projected outward. This could then be used as a master to imprint other discs, making it possible to quickly mass-produce records. After experimenting with different materials, Berliner settled on using rubber and later a shellac compound for his discs. These were far easier to mass-produce, store, and were more durable than cylinders, and became the dominant format going forward.

Let's fast-forward to 1948 and the introduction of the LP (long-player). Peter Carl Goldmark made a record out of plastic vinyl that could be recorded on both sides, allowing for multiple songs on one record. Although traditional records stayed in the market for decades, the LP took sound recording to the next level. The LP helped to develop the music industry into what we know today.

In the 1960s and 1970s, turntables became a lot more popular commercially, with the introduction of stereo playback. They used the same concept as phonographs and gramophones but with electrical components, making them more efficient and easier to use. Stereo playback could produce louder and clearer sounds.

Skip back a bit towards the late 1950s, though, and alongside vinyls was the creation of the RCA magnetic tape, yet again revolutionizing the music industry. It wasn't an instant success, but it allowed recording on a smaller device for greater portability. Car manufacturers using this technology led to the tape's rapid rise in popularity, and by the late 1960s many cars offered eight-track players. For the first time it was possible to listen to music while you drove.

Sony hit the nail on the head with the Walkman in 1979, transforming personal audio listening to a very similar form factor to what's used today—the personal music player. You could take cassette music with you anywhere you wanted. The freedom this gave was massive, and has only been improved on since.

THE DIGITAL AGE

The mid 80s saw the rise of the digital era. CDs took full form and flooded the music market. A "compact disc" version of a record, it required lasers to read the data off of a track instead of a needle. A smaller form factor made production easier and more accessible.

Unfortunately, CDs started to plummet in the early 2000s with the introduction of online music sites such as Napster. Piracy became a huge problem, hitting the music industry hard as illegal file-sharing of music boomed. The damage was done immediately, and sharing music on the internet remains to this day.

Personal digital audio listening became huge as the Walkman was replaced by MP3 players and the mega-popular iPod. It was now possible to store whole libraries of your favorite music right in your pocket with one of these devices, creating a huge increase in download sales. Also, with CD burning you could take your beloved CDs and turn them into MP3 files. Although CD sales dwindled more and more, they were and are still usable today.

Thomas A. Edison
GEM

The wax cylinder phonograph helped set us on the path to home audio bliss.

The Walkman revolutionized the way we listen to music.

© CALLMEFRED.COM ON UNSPLASH

sounds lift games to a whole new level of realism and immersion.

LPs were another major step forward in home music listening.

The final step in the journey was the introduction of music-streaming sites in the mid 2000s, paving the way for the future of music listening and the decline of physical copies. It's given people the opportunity to access music at the click of a button. Sites like Spotify in 2011 managed to license a huge library of music—the first one to do so. From then on, streaming music has become the most popular and accessible way to listen to songs. Music is with us everywhere we go now, and we have quick and easy access to the world's library of music at our fingertips on almost any device.

© GETTY IMAGES

AUDIO'S IMPACT ON THE GAMING WORLD

TO PUT IT LIGHTLY, sound is colossal when it comes to gaming, and has been even back from its humble beginnings. Commercial gaming started to take shape back in the 1970s. The quintessential classic game of *Pong* is as simple as it gets by today's standards. However, the implementation of the "beeps" and "bops" adds to the game. Even though you can see you have hit the shot, you get to hear it too. Strangely it's satisfying, and it gives you a feeling of confirmation without you really realizing it.

Through simple soundtracks or repetitive noises, audio can soon become a huge part of the brand identity for a game. *Pacman* is heavily known for its "waka waka" sound—you hear that and you think *Pacman*. For a gaming franchise, that is gold. In a way, sound engineering can be seen as an advertisement. It works in the same way—you hear something catchy or repetitive and it'll get stuck in your head, along with the image you pair it with. Clever, right?

Let's move on a little bit. Gaming and audio have taken another big leap forward. You may not think it straight away, but the art and engineering that goes into the audio of a game are just as important as the visuals. Sound gives a whole other dimension of immersion. It can put you straight into the center of a war-torn town, the driver's seat of a V8 muscle car, an intergalactic battleship, a desolate haunted forest. You name it, there is a sound for it. Sound sets the ambience and the scene for your mind to be taken away to another place. Audio immersion is therefore vital in video games.

BE IMMERSED

Gaming through your tv/monitor speakers seems to be something that only is done by "casual gamers" or in a social setting. Headsets are the preferred option for many when it comes to jumping online and busting up some noobs. The benefit you get from listening to games through a headset is a massive advantage over other gamers, especially in the competitive side of the gaming world. Directional audio and an increase in audio quality adds so much detail and immersion to help keep you focused in the game.

Game developers focus a significant amount of their time on perfecting sound engineering because of the importance of the ambience, and the increase in the use of headsets. Sound progression has to keep up with the rapid progression of video graphics, and for us that is extremely exciting. Gaming would be very empty without the realistic, immersive sounds we now take for granted.

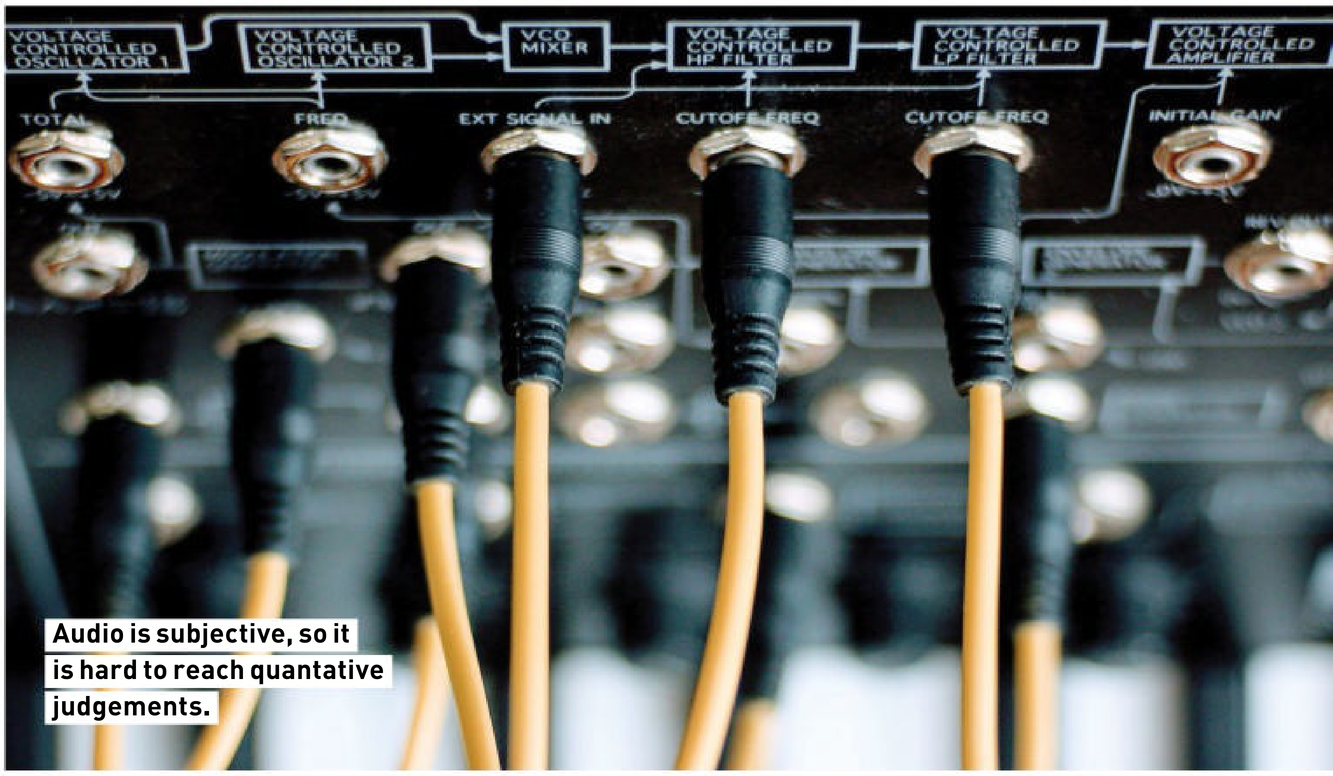
HOW DRIVERS WORK

Under the sleek outer design there's some serious tech at work.

DRIVERS ARE the main powerhouse in a headphone, creating the sound waves we pick up. It's the engine block behind the hood, if you will. Basically the science behind headphones is that each driver uses electricity and a diaphragm to compress and decompress air. This creates a vibrating pressure wave that your eardrums pick up when said compression is fast enough.

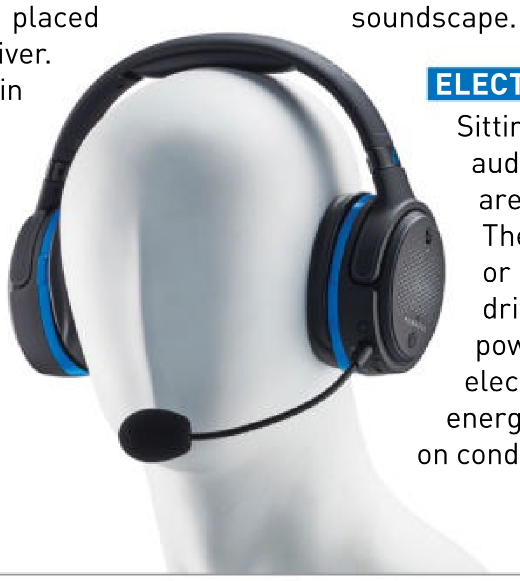
DYNAMIC DRIVERS

The most common form of driver in the headphone market by far, dynamic drivers work by using a coil of very thin wire. The electrically charged part that contains the data necessary to produce the sound is sent through it. By doing so this then creates a magnetic field reacting with a magnet that is located near the center of the driver. This electromagnetic reaction is where we start to get the wave effect. It forces the coil that is attached to the center of the diaphragm to move forward or backward in a rapid motion, the speed of which varies depending on the strength of the electrical part. As a result of this, the driver's diaphragm moves, which the coil is attached to. When this is done in a fast sequence, the surrounding air is compressed and decompressed, creating sound waves that our ears magically turn into sound. Out of the three drivers, the dynamic driver is the simplest technology, thus making it the most available driver on the market.


VOLTAGE CONTROLLED OSCILLATOR 1
VOLTAGE CONTROLLED OSCILLATOR 2
VCO MIXER
VOLTAGE CONTROLLED HP FILTER
VOLTAGE CONTROLLED LP FILTER
VOLTAGE CONTROLLED AMPLIFIER
TOTAL
FREQ
EXT SIGNAL IN
CUTOFF FREQ
CUTOFF FREQ
INITIAL GAIN
Audio is subjective, so it is hard to reach quantative judgements.

PLANAR MAGNETIC DRIVERS

Planar magnetic drivers aim to provide a far more sophisticated listening experience by reducing the degree of non-linear distortion. At higher volumes, dynamic drivers have a tendency to warp sound. However, planar magnetic headphones get around this by using two magnetic fields placed on each side of the driver. Diaphragms used in these drivers are also far lighter and are attached using a multitude of flat capacitors across its surface, instead of a wire coil in the center. This pushes the charge across the entire diaphragm rather than pushing the charged part directly through the thin wire coil to produce the vibrations. With the help of an increased surface area, it is possible to replicate sound at higher volumes without losing out to non-linear distortion. The result of this is an increase in clarity, and a much more accurate soundscape.


The rise of headphone use is driving the technology ever forward.

ELECTROSTATIC DRIVERS

Sitting proudly in the audiophile driver's throne are electrostatic drivers. They are far from cheap or portable. Electrostatic driver headphones are powered through an electrostatic amplifier or energizer. Instead of relying on conductive material to move the diaphragm, the whole diaphragm itself moves. Fitted between two metal plates is a super-fine sheet of electrically charged fabric. This way the entire diaphragm can be pushed or pulled toward either plate. The headphones produce the vibrations required to compress the air, creating sound waves with no discordance.

HOW TO MEASURE HEADPHONES

Measuring sound is divisive. Quantitative data is important when looking at a piece of audio equipment, but it isn't the be-all and end-all of what sounds good or not. Many headphone specs, such as frequency response and headphone impedance, may leave buyers confused as to what that actually means, so we will break these down now and talk about the science behind the specs.

One of the main specs looked at are drivers. Luckily we have gone through the types of driver already, just not driver size.

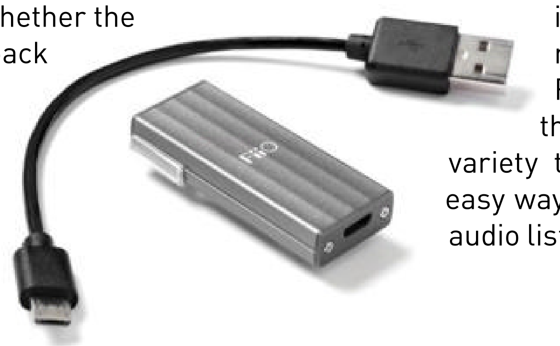
© MICHEL DIDIER JOOMUN ON UNSPLASH

Most consumers see driver size as the bigger the better. This isn't strictly true. Driver sizes range from around 6-12mm in earphones to sizes of 20-50mm in standard headphones. The general advantage of having larger drivers is more controlled bass, but it is not necessarily louder and more powerful. The type of driver is more important in understanding how a driver sounds.

Another key spec found on headphones is impedance, whichis measured in ohms (Ω). The lower this is, the less power you will need to drive the headphones, and vice versa. If a headphone has an impedance of 1-32ohm it can be powered by something like a smartphone. 33-100ohm may require a portable amplifier to push a high volume out of the headphones. If it is over 100ohm you'll need an amplifier—portable devices won't have the oomph to power these. The higher the ohm the better the headphones treat the electrical current, producing richer sound.

Finally, frequency response is a phrase thrown around by a lot of manufacturers. It's measured in Hz or kHz. Humans can only really hear frequencies of up to 20,000Hz at the most, so why would manufacturers boast of frequencies up to 60,000Hz? Well, generally this means that the headphones have no problems reproducing sounds in the very high frequencies.

Overall, the main specs to look out for when looking at headphones are the actual type of driver, the size, and the impedance level. These should give you a general idea of whether the headphones will pack a punch or not.



A DAC can help you unlock your setup's full audio potential.

© GETTY IMAGES

IMPROVE YOUR SETUP

IF YOU ARE AN AUDIOHEAD with a good pair of headphones looking to get more out of them, then you could be after a DAC / headphone amp. A digital audio converter takes digital data and transforms it into an analog audio signal. This audio output signal is then sent through a pre-amp and into an amplifier. When you are listening to a digital recording, you are actually listening to an analog signal that's already been converted by a DAC. Without DACs we wouldn't be able to experience the benefits of digital audio. When a record is being produced, the sound is recorded in analog and converted to digital for storage purposes. The DAC simply decodes this back to analog for it to be listenable.

By improving your DAC, you will be able to produce a sound quality far superior to that of your measly phone or standard PC's integrated sound card. A DAC converts a bitstream of 1s and 0s into analog signals. Unfortunately it doesn't always convert these to a consistent timing sequence, resulting in what is known as "clocking errors." It sounds more confusing than it is. In playback, you will hear "clocking errors" as a jitter. Standard DACs found in phones and computers aren't as well-equipped to deal with clocking errors, resulting in more jitter. Most external DACs are set up to deal with these issues.

For most PCs and phones the best bet is to use a USB DAC—most are plug and play. For home stereo setups, there's a much wider variety to choose from. It is an easy way to improve your existing audio listening experience.

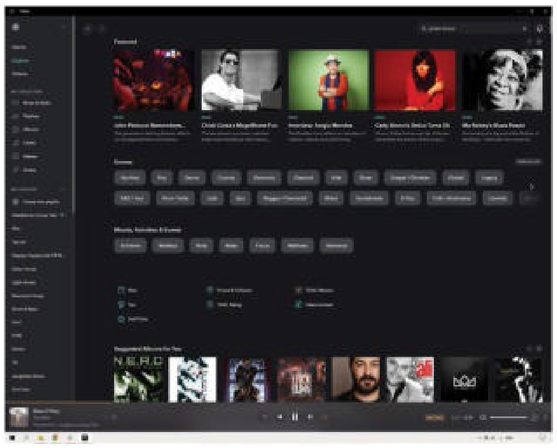
HOW WE TESTED

AUDIO TESTING falls into another category of testing for us at *Maximum PC*—it's not as simple as running it through some software, getting some numbers, and sticking it in a fancy bar chart. "Subjective" is one way to put it. The true nature of sound testing falls into the ears of the listener, and unfortunately quantitative data doesn't always paint a perfect picture. For our headphones here, we have a few tests that they have all had to face. We have gaming headsets too, so we wanted to see how well they all perform for both music listening and gaming.

Firstly, we wanted fair and honest group testing. Before listening, we delved into the sound settings in Windows to make sure that the default format for all the headphones and headsets was running at the highest possible bit and Hz rating they could. This ensured that the headphones weren't restricted via a software setting. No EQs have been used either, as this could favor some and disadvantage others.

We picked Tidal as the streaming site of choice. Tidal offers some of the best-quality streaming on the market right now, with lossless audio files, ensuring that we're not faulting the headphones because of poor-quality files. We selected a range of genres when choosing the tracks, making sure that they are all master files in Tidal—the highest quality you can get on the site.

For gaming, we didn't mess around with EQs in the game and just used default settings. We tested on *Call of Duty Modern Warfare: Warzone*, *Forza Horizon 4*, *Alien Isolation*, and *Grand Theft Auto V*. Using a range of games and song genres should show how the headphones handle different aspects of audio listening, and whether they perform well under the pressure, or crumble.



Tidal's streaming service offers extremely high-quality audio files.

X by Kygo A11/800 $249

X BY KYGO is a fairly new brand imagined by Norwegian DJ Kygo himself. This pair, the A11/800, fit towards the higher end of the lineup, with a simple yet effective mono-colored look.

As far as build quality goes, these headphones aren't up there with the likes of Bose. These are lightweight, mainly plastic cans—though that's not a bad thing, as wearing these for a long time is no problem at all. However, they are prone to creaking, which is its downfall when it comes to quality. Cup size is not as large as others, favoring the smaller eared out there, and they are a snug fit, with padding being more of a springy sponge. They aren't uncomfortable, but a softer foam would probably improve these cans.

The A11/800 offers auxiliary input, which is always a bonus, as well as Bluetooth 5.0. It's charged via USB-C, with a fast charge time of two hours. A full charge will provide you with around 40 hours of listening via Bluetooth, which is awesome. However, if you have active noise-canceling on, that'll fall to 19 hours.

On the right earcup, you have swiping touch controls that work consistently. There are also buttons for the ambient mode, power, and active noise-canceling. It's not class-leading but works pretty effectively, with the only issue being a very quiet buzz when the headphones are on with no music playing. Ambient mode works well, enabling you to communicate without having to take the pair off.

The A11/800 has a decent soundscape. When testing songs, it seems balanced across all the genres, not favoring one in particular. The detail comes in at the high ends but lacks bass on the whole. At higher volumes, we hoped this would come to life, but not quite. Gaming isn't too great. They do the job, but the lack of bass doesn't favor some of the environmental sounds in games that give you that full immersion. Overall they are capable headphones—just a few tweaks and better build quality would help these against the big guns.

SPECIFICATIONS

Driver	40mm Dynamic
Frequency Response	15 Hz-22,000 Hz
Impedance	32 ohm
Connectivity	Bluetooth 5.0, 3.5mm jack, USB-C charging
Design Style	Closed back
Weight	8.8 oz

VERDICT 7

X by Kygo A11/800

LOOKS THE PART Strong high end; clean sound; good subtle styling.

A FEW MISSING PIECES Cheap feel; bass lacking; smaller earcups.

www.xbykygo.com

Sony WH-1000XM4 $348

AT FIRST GLANCE, you might not get the sense that these headphones contain some serious power under the hood, as this power is hidden under an elegant and sleek body. Its smooth matte mono-colored finish pushes the idea that Sony wanted sophistication with substance.

Comfort is great with the WH-1000XM4. Slightly more padding on the headband and cups may be helpful, but using these headphones all day feels almost effortless. The memory foam soft-touch leather creates a perfect cushion for your ears.

The headphones are seriously feature-packed. Active noise-cancellation plays a huge part in the immersive experience. Without playing music, they cut pretty much all background noise out. They are great for VOIP, while using the ambient mode is great for communicating without interrupting your musical listening experience. All these features don't seem to affect the battery life, as you can get 30 hours of playtime with ANC on. Google Assistant and Alexa are also integrated, for all of you virtual assistant lovers out there. Along with this, the right cup is where you find the touch playback controls, again keeping Sony on the forefront of features and ensuring a seamless listening experience.

We probably should mention that they sound amazing! The headphones produce a progressive and powerful soundstage, treating your ears to copious amounts of bass and crystal-clear clarity at the top end. Sony's 360 Reality Audio is excellent when paired with a supporting streaming site such as Tidal. The sound produced engulfs you.

As far as gaming goes, the result is very similar—you feel a part of the game.

The only few setbacks include an inadequate mic, no water resistance, and the use of plastic over some more premium materials. Nevertheless, they produce magnificent sound and boast market-leading noise-canceling technology.

SPECIFICATIONS

Driver	40mm Dynamic
Frequency Response	4 Hz-40,000 Hz
Impedance	47 ohm
Connectivity	3.5mm jack, Bluetooth 5.0, USB-C charging
Design Style	Closed back
Weight	8.8 oz

VERDICT 9

Sony WH-1000XM4

PACKS A PUNCH Great soundstage; cloud-like comfort; full of features; market-leading active noise-cancelling.

GAPS IN THE GUARD Not water resistance; call qualities are lacking; lots of plastic.

www.sony.com

Sennheiser HD450BT Wireless $200

YOU ALL KNOW of Sennheiser, as an audio powerhouse at the forefront of sound. The HD450BT is a very well-rounded pair of headphones, sitting in the company's low to mid-range price bracket at $200.

For this price, you get premium features expected in more expensive headphones, such as active noise-canceling, dedicated app support, and a variety of onboard controls, which are found on the right cup. You get buttons for volume, dedicated voice assistant, noise-canceling, and power. A slider controls the playback features to skip songs, and you can press it to play or pause. Alongside that, there is the 3.5mm jack and a USB-C charging port. When charged to full capacity, you can get around 30 hours of playback out of these cans, and that's with active noise-canceling in play. The ANC is impressive, too.

The premium continues with a very satisfying performance. Throw any genre at these headphones and they put up a good fight. The sound is clear and detailed rather than heavily bass-focused. That's not to say they are lacking in that department, they just score better in the mid to high range. Voices and higher pitched instruments are crisp.

Gaming isn't the HD450BT's forte—sound feels quite flat during sessions.

The premium feel can't quite be said about the build quality, with a plastic structure and no metal finishes in sight. It's a shame that Sennheiser had to cut corners in this area. They feel sturdy enough, it just brings the product down slightly from others in the same price range. The headband is also not the greatest due to thin padding, but luckily the earcups don't suffer from the same fate and are very comfortable.

The HD450BT is well-rounded and offers high audio quality for a reasonable price range. It handles most things well, looks stylish, and has premium features usually found at higher price points. If you can overlook the materials, it's a good purchase for the price.

SPECIFICATIONS

Driver	32mm Dynamic
Frequency Response	18 Hz-22,000 Hz
Impedance	21 ohm
Connectivity	Bluetooth 5.0, 3.5mm jack, USB C charging
Design Style	Closed back
Weight	8.4 oz

VERDICT 7

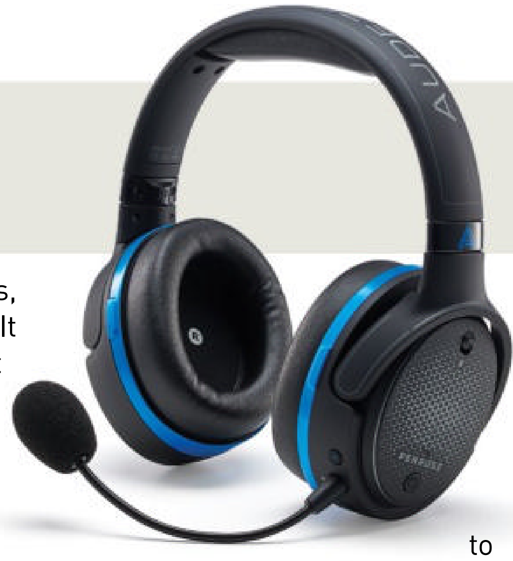
Sennheiser HD450BT Wireless Headphones

⊞ **SOLID SENNHEISER** Good value for money; clear soundscape; great battery; well rounded.

⊟ **ALMOST THERE** Cheap materials; could be bassier; comfier headband needed.

www.en-us.sennheiser.com

Audeze Penrose Planar Magnetic Headset $299



AUDEZE has used its phenomenal audio knowledge to create a very solid gaming headset. The company is more traditionally known for high-end planar magnetic headphones but has dipped into the world of gaming with the Penrose.

The headset has some good weight to it and a real sense of rigidity. The cups are large and deep (probably due to those huge 100mm drivers), offering comfort for listeners. The super-soft earcup pads also help deliver good comfort levels.

Looks are subjective, and this pair comes in black and blue, or black and green, which may not appeal to everyone, and might not be a pair you want to commute around with too much.

This headset has all the connectivity requirements you could ask for; wireless 2.4GHz via USB dongle, Bluetooth, and a good ol' 3.5mm jack. The right cup is empty, while the left cup has all the ports—one for the detachable microphone (which sounds good), USB-C charging port, volume rockers for the output and microphone, a mute button, switch button for different connectivity options, and the power button. It doesn't have the latest touch controls, but they can often be more of a hindrance anyway.

Audeze has achieved a rich and deep sound in this Penrose headset. In-game sound surrounds you, and the directional audio is pinpoint. You feel completely involved in the environment you are in—exactly what a gaming headset should do. Paired with a decent detachable microphone, it's a very good package.

When it comes down to music, it can be a bit overpowering with the bass, leaving the mids and trebles feeling a little left out. The detail is slightly drowned out, but overall these cans sound great. However, for the price, you can find better music listening options out there.

SPECIFICATIONS

Driver	100mm Planar Magnetic
Frequency Response	10 Hz-50,000 Hz
Impedance	N/A
Connectivity	2.4GHz Wireless, Bluetooth 5.0, 3.5mm jack, USB-C charging
Design Style	Closed back
Weight	11.3 oz

VERDICT 8

Audeze Penrose Planar Magnetic Headset

⊞ **BRINGING PLANAR TO GAMING** Premium build quality; rich sound; great connectivity; decent microphone.

⊟ **A FEW MISSING PIECES** Subjective styling; expensive can; trebles and mids can feel drowned out.

www.audeze.com

MSI Immerse GH50 Gaming Headset $75

SITTING AT the budget end of the headsets we have in this battle is MSI with its Immerse GH50 cans. They are a decent-looking pair, with a gunmetal-gray finish and an RGB MSI emblem sitting proudly on each cup. The RGB is quite subtle, at least.

The design relies on a simplistic approach, with no physical buttons on the headphones, instead opting for an in-line remote. This houses the volume control wheel, mute button, 7.1 virtual surround sound button, and vibration activation control. The materials on the cups and the headband are comfortable, but thanks to the tight tension of the headband they are not the comfiest pair, fitting a little too snugly on your skull.

Bearing in mind the price, this headset produces a powerful sound, with bass at the forefront. MSI's vibration system is its take on haptic sound. As gimmicky as it may come across, it plays well in certain aspects. In bass-driven songs, it puts you in the middle of the sound. On the flip side, the GH50 suffers from a lack of clarity at the high end, muddying the sound, and the vibration system can overpower what you are listening to, squashing the mids and highs.

As for gaming, the directional audio is superb. It feels like you've been chucked right into the game. Unfortunately, the virtual 7.1 surround sound feature is a bit lacking—in fact it actually appears to lower the audio quality in some cases. Your best bet is to leave it turned off and have the vibration activation control on.

SPECIFICATIONS

Driver	40mm Dynamic
Frequency Response	20 Hz-20,000 Hz
Impedance	32 ohm
Connectivity	2.0 USB
Design Style	Closed back
Weight	10.6 oz

The GH50 is a solid bet for a good gaming experience with a lower budget. It produces a solid bass and has great directional audio. When it comes to in-game voice chat, the detachable microphone is equally impressive, delivering clear audio. However, the GH50 lacks detail at the higher end of the frequency band. The lack of Bluetooth connectivity could also be an issue, as the headset is only connected through a USB-A braided cable.

VERDICT 7

MSI Immerse GH50 Gaming Headset

+ **BATHE IN BASS** Strong low end; clean look; great mic; solid gaming immersion.

− **OUT OF THE IMMERSION** Poor connectivity options; gimmicky features; not too comfy.

www.msi.com

The home of technology
techradar.com

Razer Blackshark V2 $100

AS FAR AS gaming peripherals are concerned, Razer seems to know how to make a strong product. As soon as you open the box you're greeted with a card declaring: "Sound is just as important as sight when you're in-game." It's not wrong, and the Blackshark V2 is a good example of this. It sits in the budget end of the group here, but don't let the price fool you.

Razer has created an awesome-looking headset, with aviation its aesthetic theme. The finish is matte black plastic that feels good to the touch, with green accents and of course the Razer logo. It feels light on your skull and is paired with breathable memory foam pads, so you can expect to get hours of gaming out of these before things start to become uncomfortable. There are very few buttons—you get a mute button and a volume rocker. This is due to the lack of Bluetooth connectivity or any noise-canceling features. However, Razer does offer this headset with wireless connectivity for an extra 70 bucks.

Call of Duty with this headset is great—all of the sound elements seem to be prioritized. Directional audio is very accurate, and the bass is right in your face. Razer has stuck to its message about the importance of sound in gaming. Bass is layered and deep, and the highs are clear for those intricate details that give you that extra edge.

This headset is pretty strong for music too, offering a solid sound through all of our tested songs, favoring more rock music if anything. Its sound is powerful, and you'll be more than happy using it for both types of listening styles, although it does perform stronger in its target market.

The Razer Blackshark V2, then, delivers very good bang for your buck. The fact that it's lacking some of the more high-end features seen in this battle doesn't stop it from being a strong competitor. It punches above its weight and is a solid headset for anyone looking for an immersive experience for 100 bucks.

SPECIFICATIONS

Driver	50mm Dynamic
Frequency Response	12 Hz-28,000 Hz
Impedance	32 ohm
Connectivity	3.5mm jack, USB sound card
Design Style	Closed back
Weight	9.2 oz

VERDICT
8

Razer Blackshark V2

GREAT GAMING IMMERSION Brilliant budget headset; strong atmospheric sound; good mic.

NOT QUITE THE MUSICIAN Lacking features; hardwired; a little flat for music listening.

www.razer.com

Logitech Pro X Wireless $200

LOGITECH and peripherals go hand in hand. The Pro X wireless is Logitech's range-topping gaming headset, and you get a sense of this straight out of the box with the build quality, design, and sturdiness of the Pro X wireless.

It's another headset that's aviation-themed, but Logitech takes it that one step further by using more premium materials. The exposed headband forks are thick metal, making the earcups feel very rigid. The logo sits on a shiny, grooved-metal ring plate that stands out from the black headset, but in a way that's not obnoxious. It is one of the heaviest headsets we have on test, but with its thick headband and thick, soft cups, comfort issues aren't apparent for several hours of use.

The Pro X wireless is connected via a USB dongle only, so connectivity is lacking. This is a real downside for the headset—in this price range you'd expect multiple connectivity options. On the left cup, there is a USB-C charging port. A full charge will give you 20 hours of gaming, which in its class is less than expected. However, you're probably going to want some sort of a break within that time, so this shouldn't be an issue. You'll also find the volume rocker on the left cup, which glides perfectly—it's small details like this that distinguish the good from the great when it comes to the build quality. There is also a dedicated mute button—always handy for gaming—and a detachable mic port.

Talking of the mic, the sound quality picked up is clear, and you should have no issues communicating.

When dropped into a gaming environment, the PRO X shines. Sounds are heavily detailed, but a slight lack of bass can result in less immersion than desired. Where the headset suffers is in the high ends. Sounds can often be too sharp in certain situations, which can come across in our music test. Overall it's a solid purchase, but a higher price doesn't always result in a better sound.

SPECIFICATIONS

Driver	50mm Dynamic
Frequency Response	20Hz-20,000 Hz
Impedance	32 ohm
Connectivity	3.5mm jack, USB sound card
Design Style	Closed back
Weight	13.0 oz

VERDICT
7

Logitech Pro X Wireless

METAL TRIM IS A WIN Great build; very comfortable; strong sound on the whole; decent mic.

HEAVY PRICE Lack of connectivity; can be sharp at the high ends; needs a bit more bass.

www.logitechg.com

Corsair HS60 Haptic $120

IF WHITE CAMO is your thing, or you can overlook the fact that this is white camo, then the HS60 is a good contender for this battle. Looks aren't everything, remember.

The HS60 Haptic is competitively priced at around $120. Haptic bass has been a subjective technology in headphones for a while now, but it's not often included on more premium products. A lot of the time it's seen as gimmicky, but the HS60 tackles this well.

On the right cup, you have a toggle wheel that controls the amount of haptic feedback you want. Instead of being either on full whack or off—leaving the audio a little flat at times—you can adjust it to your liking. On the right cup is where the volume rocker, mute button, fixed USB-C cable, and a port for a detachable microphone can be found. The mic's quality is pretty clear and should be more than adequate for your gaming needs.

Onto the construction, and this is a big positive for Corsair, feeling more premium than the price may suggest. It's well put together and has some decent weight to it, but not enough to make you feel uncomfortable. The earcups and headband are plush with subtle white stitching to finish it off.

Haptic bass certainly works better with the punchier songs—it carries the bassline and just charges them with more oomph. If you haven't experienced it before, it's certainly interesting. In some areas it works really well, but of course when you have too much bass it swallows the rest of the song. Fortunately, the toggle wheel is not far away to change this. Chuck yourself into a game and the haptic feedback makes a lot of sense. *Alien Isolation* gets a whole new level of scary, and environments in games like *GTA* and *Forza* feel alive.

On the whole, the HS60 confidently tackles the haptic bass feature, and the headset creates a balanced, warm sound, though could do with a bit more clarity at the high ends.

SPECIFICATIONS

Driver	50mm Dynamic
Frequency Response	20 Hz-20,000 Hz
Impedance	32 ohm
Connectivity	USB
Design Style	Closed back
Weight	14.8 oz

VERDICT

8

Corsair HS60 Haptic

+ **EXTRA LAYER OF BASS** Good audio quality; solid construction; powerful bass.

− **LITTLE BIT BASIC** Bit pricey for the level of connectivity; subjective design; needs a little more clarity.

www.corsair.com

SteelSeries Arctis 9 $170

A LOT OF HEADSETS seem to have at least one or two things that hold them back from being great, either to reduce the cost, or to help one aspect of the headset exceed at the expense of another. The Arctis 9, on the other hand, does everything that is thrown at it very well indeed.

First off, the comfort levels are amazing. When initially looking at the headband, the lack of padding was a little off-putting, but its elastic suspension alternative works exceptionally well. It takes all the weight off the headband and evens it out. Along with the breathable fabric cups, it makes for effortless comfort. It is very well-built, although some more premium materials would be welcome considering the price range. The left cup features a pull-out-style microphone that records very impressively. There is also a toggle switch for party chat/game sound when connected via the supplied PC/PS4 connection hub. On the right side is the volume rocker, mute button, Bluetooth, power button, micro USB for 20 hours of full charge, and a 3.5mm headphone jack. This headset is great for connectivity, and it also features lossless 2.4GHz wireless audio.

But what would all this matter if the audio didn't match? Luckily the sound quality is excellent too. It can be crisp and punchy at the same—perfect for the crucial details in competitive gaming, one of the Arctis 9's main USPs. Directional sound is very accurate, and the overall sound is rich and deep. Music is handled well too, with the main focus on the bass. However, it provides good clarity at the higher ends too, with sharpness very rarely being an issue.

It's a very strong competitor, managing to perform well in all scenarios. With great sound, solid build quality, and pillow-like comfort, it's very well-rounded. The gripes are minor—more premium materials would be nice, and occasional sharpness in some tracks might push away some.

SPECIFICATIONS

Driver	40mm Dynamic
Frequency Response	20 Hz-20,000 Hz
Impedance	32 ohm
Connectivity	Wireless 2.4GHz, Bluetooth 5.0, 3.5mm jack, micro USB charging
Design Style	Closed back
Weight	13.3 oz

VERDICT

9

Steelseries Arctis 9 Wireless

+ **DOES IT ALL** Superb comfort; high-end audio quality; great connectivity.

− **TINY GRIPE** Better materials found on cheaper headsets; can be a little sharp.

steelseries.com

And the champion is…

SONY WH-1000XM4

SO, how did we get here? In our little head to head, we ended up having a lot of similar scores through one reason or another. When it came to value for money, the Razer Blackshark V2 took the crown. For build quality, the Logitech Pro X wireless boasted the most premium materials and a solid feel. To come to our decision, then, it came to the overall package and what the most important factor of a set of headphones actually is—sound quality. For us, the Sony just had that wow factor. Throw anything at these headphones and the response back is bliss.

The WH-1000XM4 is just superb, to put it mildly. It is feature-packed with class-leading active noise-canceling, has seamless proximity sensors for zero interruption, and effortless touch controls. Everything on these headphones works exactly how you need it to. We know the Kygo A11/800 has very similar features, but the execution just isn't quite there with them.

The technology used in the Sony headphones makes commuting a breeze. The noise-canceling can take you away from everything, no matter where you are. On the flip side, switch it to the ambient mode, and communicating with others around you will no longer be a problem. If that isn't enough, in one setting, when you start talking it automatically switches the volume of your track down so you can hear what others are saying in a conversation. It's features like these that are sure to be seen in future headphones, and just another reason why the WH-1000XM4 has won this battle.

Another key winning point for the WH-1000XM4 is the way it looks. It brings to the table a timeless, very sleek design, and something that can be worn anywhere and everywhere. This is a big factor for those of you out there looking for a daily driver for your audio needs. The build quality is light but sturdy, resulting in great comfort levels, especially with those super-soft earcups.

A very strong competitor was the SteelSeries Arctis 9, which also scored a 9 on our verdict. Unfortunately for them, it was just the premium edge of Sony's cans and the flawless audio quality that led us to the final decision. In certain aspects the SteelSeries cans are better—the elasticated suspended headband featured on the Arctis 9 is comfier than Sony's, and it also has more connectivity options, and a better microphone. The Arctis 9 certainly works better when it comes to gaming, and is the winner when it comes to the headset domain for sure. The on-the-go factors hold the SteelSeries back a little though, with no playback controls on the headset itself, and the sound and looks just made it fall short of taking the crown from the WH-1000XM4.

IT KEEPS COMING BACK TO THE SOUND

The Sony headphones do what headphones should do: they give you the audio listening experience that the sound engineers want you to experience. All the blood, sweat, and tears they go through, their work should be embraced, and for us the WH-1000XM4 does this. Paired with Tidal's lossless streaming, and with ANC on, listening to music reaches the next level of immersion, and you really get to appreciate the art of music. Gaming is clearly not its USP, though it also performs very strongly in this regard.

As an overall package, then, and for the price, these cans do everything to a very high standard. In the end, it's just a shame about the name. ⏻

THE ULTIMATE BUDGET PC

ZAK STOREY GETS HIS HANDS DIRTY AND BUILDS THE CHEAPEST RIG POSSIBLE

IT SAYS A LOT that when we first priced this system up a month ago, it was about $295—four weeks later, and the thing sits at $387. Honestly, we feel like a broken record at this point, but the market is absolutely volatile right now, as unscrupulous folk and miners snap up every piece of hardware they can find. Even the budget end is suffering, sadly. We're finally starting to see some companies take action against this (namely Nvidia with its RTX 3060 plans), but it might just be too little, too late.

Our opinion? It's not likely to stabilize for another year, if that. Similar to the memory-shortage crisis three years back (when a set of 32GB memory would cost you nearly $500), there's just not enough fab time out there to cater for the entire market. Nonetheless, this got us thinking: what exactly is the cheapest system you can buy today, with new parts and decent performance, and get the most bang for your buck?

And with that simple question, the Budget Buster was born, a $300-400(ish, depending on time of reading) masterpiece of super low-spec, low-price PC-building awesomeness. Genuinely, this build is one of the most fun ones we've done for some time. That might sound crazy, but there's something about getting back to the bare bones of PC building that's refreshing. It makes you think, it challenges you as you lose access to a lot of quality-of-life improvements, and it's good to see just what is available at the lower end of the spectrum in regards to parts and performance.

PC building's not always about crazy, high-end systems with $4,000 worth of components, and enough RGB to light up Times Square. In fact it's something we've always argued—the smaller your budget is, the more valuable your buck becomes when allocating it to separate components. So how did we do it? Read on to find out.

INGREDIENTS

PART		PRICE
Processor	Intel Core i3-10100	$120
Memory	8GB (2x 4GB) Corsair Vengeance LPX DDR4 @ 3000 MHz	$50
Motherboard	MSI H410M-C PRO Micro-ATX	$80
Storage	240GB Kingston A400 2.5-inch SSD	$35
Power Supply	450W Corsair CV450 80+ Bronze Non-Modular PSU	$50
Case	Corsair Carbide Series SPEC-05 ATX Tower	$52
Total		**$387**

PRICES CORRECT AT TIME OF PRINTING.

CPU

INTEL CORE I3-10100 $120

WE'VE USED our trusty Core i3-10100 processor before, and it's still our budget chip of choice. Complete with four cores, eight threads, integrated graphics, and a comfortable 4.3GHz turbo clock speed, it's a fantastic option for anyone looking for a budget chip to sink their teeth into.

INTEL CORE i3
i3-10100
SRH3N 3.60GHZ
V023E527

ALTERNATIVE PICK

The **AMD Ryzen 3 3200G** is an epic alternative, and has similar performance. It usually retails for around $100, but is currently only available for $200+.

INTEL STOCK COOLER

INTEL'S STOCK cooler hasn't changed much in the last 10 years, and it's certainly not a patch on the likes of AMD's included Wraith coolers, that's for sure. However, the LGA 1200 version is slightly larger, and still does the job admirably.

POWER SUPPLY

450W CORSAIR CV450 80+ BRONZE $50

PLEASE, please never skimp on your power supply! Ever. It's just a bad idea. In our case we've gone with the super-affordable Corsair CV450 80+ Bronze. It's a non-modular PSU, but comes with a three-year warranty and a 100,000-hour MTBF rate, so if things go wrong, we know we're covered.

CORSAIR
CORSAIR
CV450

ALTERNATIVE PICK

Save a bit of cash by going with an **EVGA 450 BR** ($42), or something similar—but whatever you do, stick with a named brand and a decent warranty.

CASE

CORSAIR CARBIDE SERIES SPEC-05 $52

CHEAP and cheerful is the name of the game here, and for our chassis we've gone with Corsair's SPEC-05 ATX mid-tower case. It's roomy, has acceptable cable management, and can even support up to a 240mm AIO. Best of all, it comes with a red LED intake fan mounted up front, and an acrylic window, which is pretty awesome for $52.

ALTERNATIVE PICK

If you want to save a bit extra, the **Metallic Gear Neo Silent** is available for around $45. Although airflow is a bit limited, it does come with tempered glass instead of acrylic.

STORAGE

240GB KINGSTON A400 2.5-INCH SSD $35

WHEN it comes to storage, compromises have to be made, and since this rig isn't really designed for anything more than light office work, we've ditched the larger capacity SSDs for something a little older, and a little more quaint. Kingston's A400 2.5-inch SATA SSD fits the bill here. It might not be as potent as modern-day drives, but with 500MB read speeds and 350MB write speeds, it should be able to handle light office work and web browsing.

ALTERNATIVE PICK

At this price range we'd recommend staying away from QLC drives. However, you can pick up a **250GB Samsung 860 EVO** for just $5 more to max out write speeds.

VENGEANCE LPX
VENGEANCE LPX
DDR4

MEMORY

8GB *(2X4GB)* CORSAIR VENGEANCE LPX DDR4 @ 3000 MHZ $50

ANOTHER old faithful, Corsair's low-profile Vengeance memory is a perfect pick for this build. Although 8GB is a little on the low side, it should be enough for any office PC or simple home internet-browsing machine. Bear in mind, however, that our motherboard only has two DIMM slots, so if you want more RAM later down the line, it'd be wise to invest up front in a 16GB kit.

ALTERNATIVE PICK

You won't find huge savings in memory right now at this spec, but G.Skill sells an **Aegis 8GB** kit for $41, albeit with a speed of 2400MHz, which is less than ideal for Ryzen.

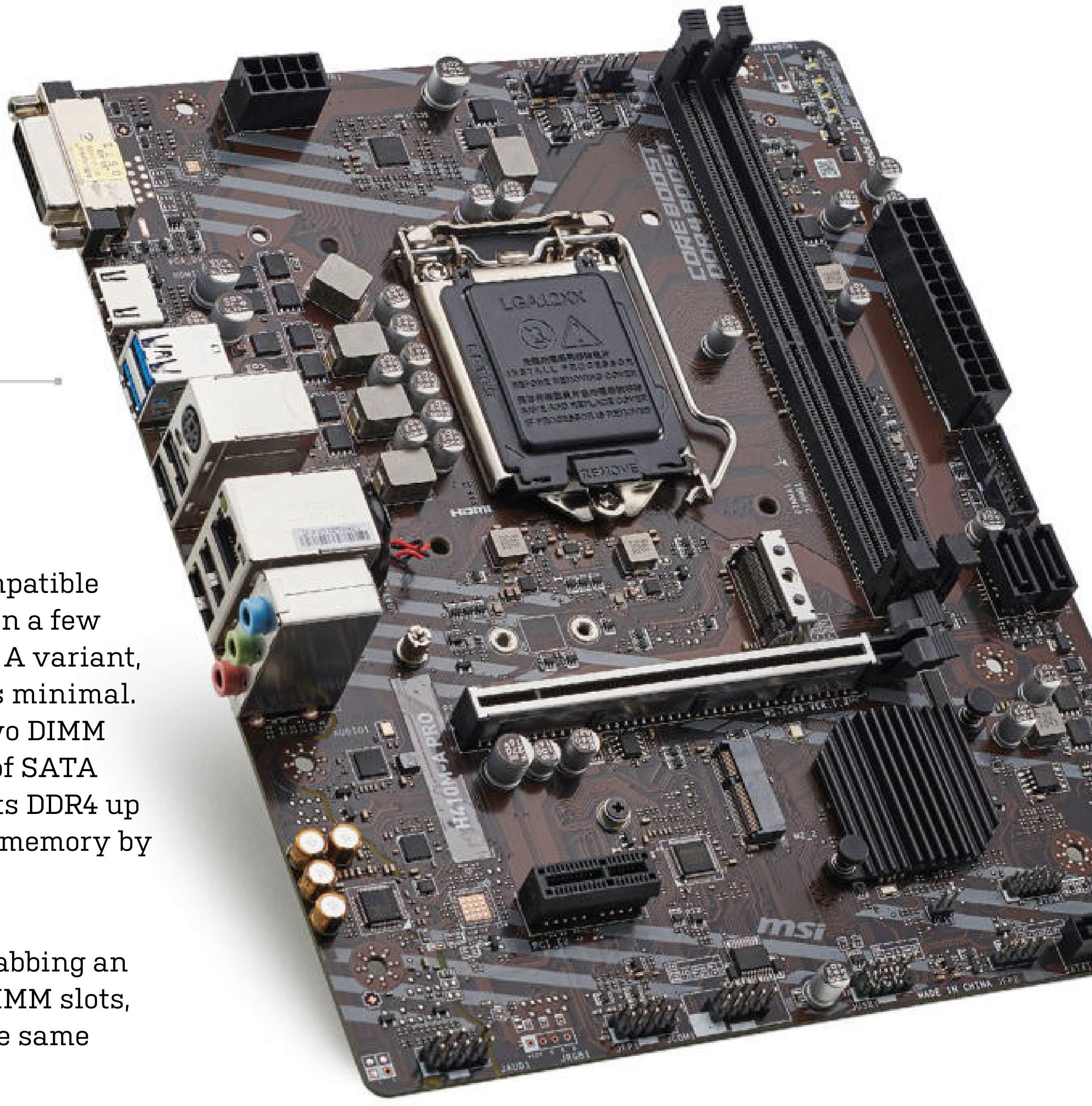
MOTHERBOARD

MSI H410M-C PRO MICRO-ATX $80

THE cheapest board we could find that's compatible with our needs, the MSI H410M PRO comes in a few designations. We're using the slightly older A variant, but the difference between that and the C is minimal. It's super-budget, comes with an M.2 slot, two DIMM slots, one chassis fan header, and a couple of SATA ports. Any downsides? Well, it only supports DDR4 up to 2933MHz, so you'll have to de-clock your memory by one level during BIOS configuration.

ALTERNATIVE PICK

For an AMD equivalent we'd recommend grabbing an **ASRock B450M PRO4**. It comes with more DIMM slots, and better memory support too, for about the same price as our MSI mobo.



THE BUDGET BUSTER

GET HANDS-ON AND BUILD YOUR OWN SUPER-CHEAP SYSTEM

SO THE CONCEPT around this is pretty simple—we just love the idea behind the Core i3-10100. When this editor first joined the tech industry, the crème de la crème of desktop processors was whatever quad-core, Hyper-Threaded chip Intel had to offer at the time. That was the end goal. Ryzen wasn't yet a thing, and anything more than four cores was relegated to the world of HEDT, which was a bit more inaccessible. Motherboards were more expensive, and memory costs immediately shot up whenever you mentioned the phrase "quad-channel."

Fast forward to 2020, and with the launch of Intel's latest chips, this little beauty fell into our lap. Well, it was a special request we put in with Intel really, because bizarrely most agencies, PRs, publications, and tech journo outlets don't spend a lot of time on the small stuff—which is a shame, because it's fascinating to see how an Intel Core i9-10900K or Ryzen 9 5950X gets filtered down into the lower specced parts, and how they perform in contrast. Many of you will remember that Christian built a solid "office" PC back in our Holiday edition that featured this chip. But this was in a lot of ways quite gluttonous: the price tag was just a bit too high, so it got us thinking; "What is the cheapest PC you can build with this processor at its heart?"

This is what we ended up with. It took a few months to get the parts together, mostly because, again, companies don't like showcasing their budget ranges, but after some nagging of management, and a few expense forms, we managed to get everything together that we needed to make this little beauty come to life.

Now, you can make this build even cheaper. Instead of that Core i3-10100 you could pick up an Intel Pentium Gold G6400 for $64, swap the memory out for the G.Skill Aegis kit, go for the EVGA 450 BR power supply we recommended, and a Rosewill FBM-01 MicroATX tower for $25, and build yourself a rig for just $282.95. However, you would be cutting your core and thread count in half by doing so, and crippling your memory and CPU speeds in the process, which is not so good.

So with that all wrapped up, let's get to building this magnificent wee beauty, shall we?

LENGTH OF TIME **1 HOUR** LEVEL OF DIFFICULTY **EASY**

1 STRIP AWAY

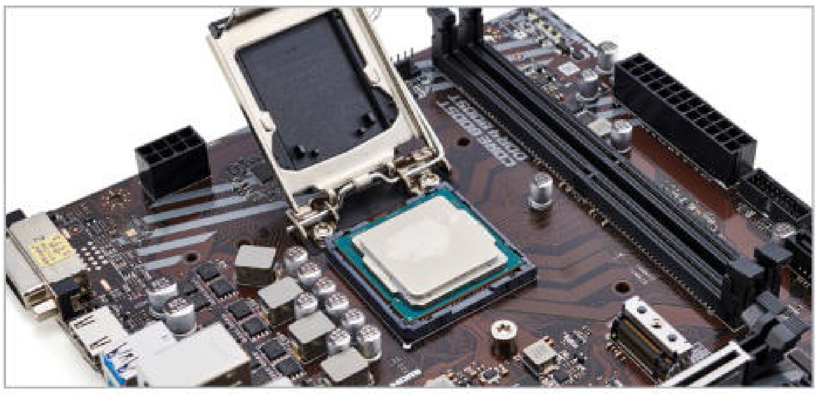
WHEN IT COMES to building a system for the first time, it doesn't matter if you're a 20-year veteran, or an absolute beginner; the first thing you should always do is start with the case itself. Study it, analyze it, and then carefully remove the panels and place them in the case box, in between the Styrofoam packaging. This way you can ensure that you don't damage or scratch them, and you won't lose them either.

With the SPEC-05, this is a simple process. The front pops off from the bottom (carefully pull away from the bottom toward you), the rear panel is held on by two thumb screws (of the non-retainable variety, so pop these in a bowl, or somewhere you won't lose them), and then the acrylic windowed panel rather bizarrely comes off with hex key screws. After that you can remove the hard drive caddies, and put the small box of accessories out the way. Once that's all done your case should look like ours here.

2 PROCESSOR INSTALL

IT'S TIME TO prep the mobo. You can do this inside the chassis, but we recommend doing it outside the case first, so you can test the system before installing it, and if anything fails to function properly, it's a far easier job to disassemble the whole thing, get it boxed up and shipped back to the supplier or manufacturer.

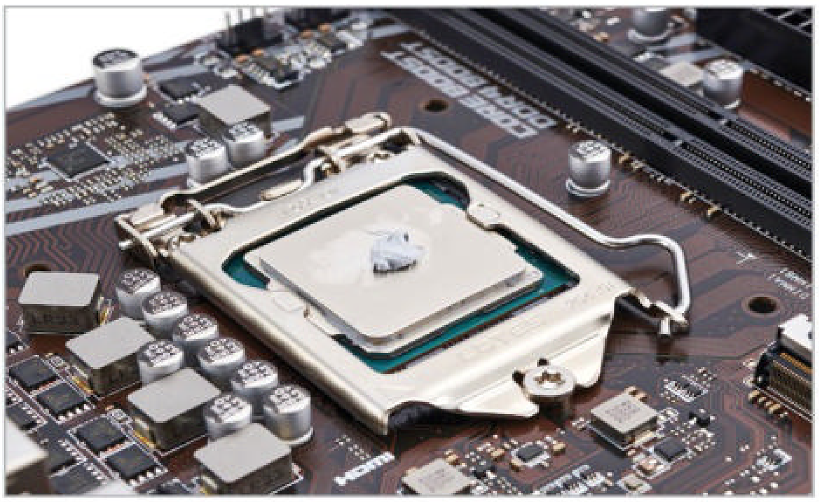
We've begun by installing the processor. This can be a bit sketchy with Intel, as the socket has pins in it that can be bent or broken. And if you bend them, not only will the system not boot, but you'll likely void the warranty too. To install the processor, lift up the retention arm, raise the bracket (leaving the plastic cover on), then carefully line your processor up with the socket, paying attention to the gold triangle on the bottom-left corner of the processor, and the socket, then gently lower it into place. Position the bracket down over the chip, under the Torx screw, and resecure it with the retention arm. The plastic cover should pop off.



3 THERMAL PASTE TIME

IF YOU'RE building this stock, you can jump to the fourth step, as the stock cooler should have some pre-applied thermal paste on the bottom of it. In our case, we're not so lucky, so we've applied non-conductive Noctua paste ourselves. To do this, squeeze a splodge of the stuff into the middle of the processor like we've done below. Make sure it's at least the size of a grain of rice. You can add more—it won't affect performance in any meaningful way, but it does mean if you remove the cooler later, you may have some mess to clean up. Just make sure your paste is non-conductive, and that you meet the minimum amount we recommend.

This varies according to the processor. HEDT processors require a line or star of paste, and AMD's Ryzen chips require a little extra too.



4 COOL BEANS

NOW IT'S TIME to install the Intel stock cooler. If you've installed one of these before, we'll just say that nothing's changed with the LGA 1200. There's no backplate required, and no adjustments that need to be made. Make sure all four mounting pegs have the little arrow facing backward. Line the cooler up with the holes in the mobo, and carefully push it down until it clicks into position on each of the four corners.

Don't do what we did and assume you then have to turn those four pegs to lock them in place as the arrow suggests—weirdly that unlocked the cooler for us, so we had to remount it again. Then, unhook the fan cable from its mounts on the cooler, and plug it into the CPU fan header on the mobo. In our case we've tied it into a little knot so it's a bit smaller.

5 MEMORY MOMENTS

WITH THE COOLER installed and the motherboard still outside the chassis, it's time to install the memory. Now, if you have a motherboard with four slots of memory, double-check with the motherboard manual which slots you should populate first. It'll likely be every other slot, but some motherboards prefer one set of slots to be occupied before the other.

In our case, as we only have two DIMM slots, we're installing our memory straight in. Lift up the tabs at either end of the slot, then carefully align your DDR4 memory so that the notches fit together. Each stick of memory and DIMM slot has a notch in it, so you can only install a stick a certain way. It's not the end of the world if you try installing it the wrong way—once you realize it's not sliding in, just remove it, spin it round, and install it again.

6 PSU CONSIDERATIONS

SO HERE'S AN interesting step that we didn't originally intend to do. More often than not we always leave PSU installation until the very end—it's sort of the last piece of the puzzle in terms of cable routing and getting everything installed, and most chassis these days (at least the ones we use) have more than ample cable management to allow that to happen.

We noticed, however, that the SPEC-05 doesn't have cable cutouts at the top of the chassis to run the eight-pin CPU power through, so we'd have to trail it up to the power port, or run it along the top of the motherboard, both of which look grim. There's a nifty workaround, but we've got to install the power supply first to do it. Slot it in to place, then secure it with the thumbscrews provided with the PSU. In any other rig we'd recommend installing the power supply with the fan facing down, but we've installed it facing up to act as an exhaust.

CORSAIR
CV450

7 SNEAKY CABLES

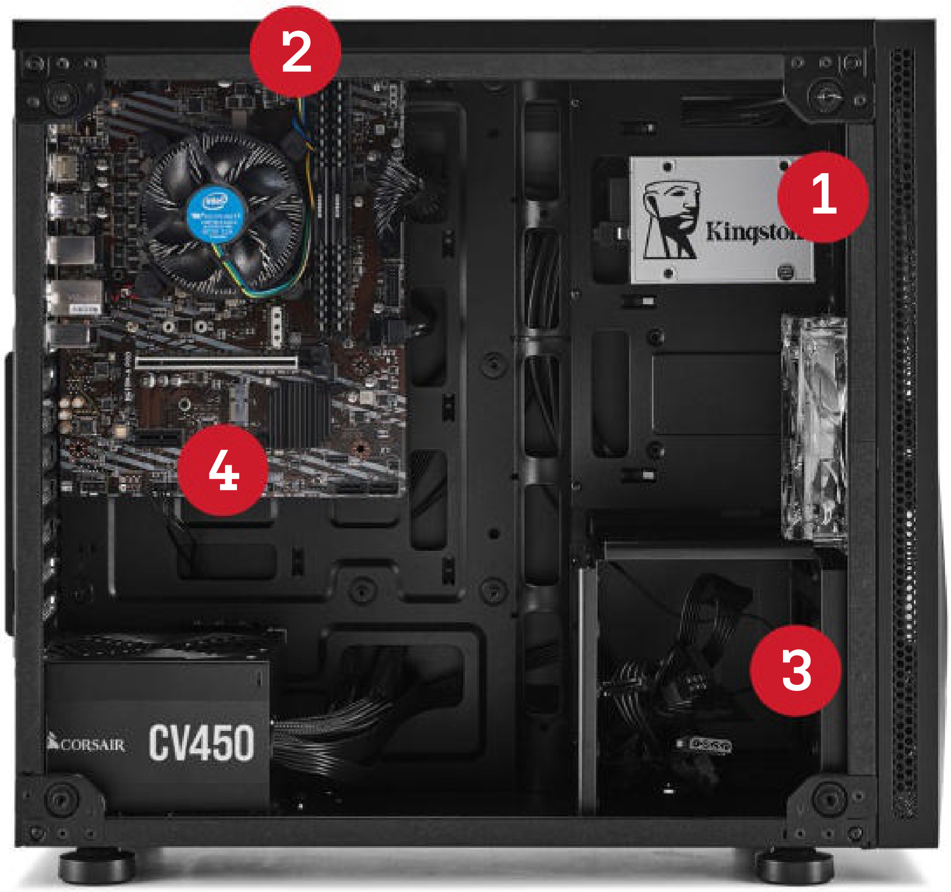
SO HERE'S THE workaround. We've installed the motherboard. To do that, install the additional standoffs in their Micro-ATX positions included in the case accessory box—these are denoted on the chassis with an imprinted M-ATX text. Place your rear I/O shield in the case (making sure to bend the protector pins up and out the way of the ports), then place your motherboard in, lining the ports up, and secure it with screws when it's over the standoffs.

However, before that final step, we've run the CPU power cable round to the back of the motherboard tray, up through the cutout that usually gives access to the CPU backplate, then underneath the motherboard, and popped it out the top. Then it's just a case of plugging it into the CPU power. This keeps the rig looking clean and tidy, and doesn't hinder or cause any problems elsewhere. With that done, we've installed the 24-pin.

8 SSD IDEAS

LAST BUT NOT least, our SSD. Traditionally you're meant to install this in the back of the case in the motherboard tray, but we've decided to install it in the front—it's a nice feature to highlight, and we've got an acrylic windowed panel, so why not? Line it up with the cutouts, and secure it with four screws from the rear. Then install one SATA power cable (from the power supply), and one SATA data cable (from the mobo box). We've gone with a right-angled data cable to make the mobo look cleaner, but it's finicky to get in the SSD, as that cutout is a little too small for installing the cable.

Once the SSD is in, secure, and powered on, it's time to wrap up the rest of the cabling. Refer to the mobo manual for your front-panel connections for power, reset and power LED. Then install your USB 2.0 and USB 3.1 headers, and that final three-pin front intake fan, and you'll be good to go.



① **You can theoretically install a 240mm AIO in the front of the case here, although it may be a bit tight, and that hard drive cage is pop-riveted into place, so there's no removing it, sadly.**

② **We've tucked the CPU fan cable down the side of the RAM to keep it out of the way, and not get tangled up if the case gets bumped or knocked. This fan's going to be doing a lot of work, so stopping it from spinning would be a death sentence for performance.**

③ **We've bundled the spare cables that we had together using cable ties, and then placed them in our empty hard drive cage. There's still plenty of space for two 3.5-inch drives on top if you need to do this.**

④ **If you want to upgrade later there's a PCIe 3.0 slot on the board for a full-length GPU, and an PCIe 3.0 M.2 slot as well.**

LA FIN!

AND THERE you have it, our attempt at building the best-value super-budget PC possible today. And hopefully by the time you read this, it hasn't skyrocketed in price to $1,800 or something ridiculous.

Nonetheless, we're quite proud of this build—it looks exceptionally clean from a custom PC perspective, even though we're using very budget-oriented parts, and managing to keep the cables tidy and out of the way has been a relatively painless process. Mounting the SSD in reverse so that it's facing toward the window looks pretty snazzy, and getting the CPU power cable behind the motherboard looks epic. Even though the board itself is only a Micro-ATX affair, all in all the system doesn't look empty—in fact it's nice to see Corsair include cable cutouts specifically for those using Micro-ATX boards in this case.

The build itself was relatively seamless. We didn't come across any major hurdles, and the biggest bugbear stemmed from the way that acrylic panel is held in place. It has screws securing it to the case, but they require a hex key to undo, which is a bit annoying, especially if you don't have a set, and there doesn't seem to be any included with the accessories box (maybe we missed it).

Performance is right where we expected it to be. The i3-10100 does well, scoring high in Cinebench, and overall performs okay (yes that is actually a high score) in our gaming benchmarks. Throw a few indie games at this thing on low to medium settings at 1080p, and you can easily achieve 20-30fps. It blisters through web apps and office applications, and that's the real take-away from this kind of machine. One thing we are curious about is how this will function if we throw in an Nvidia RTX 3060 Ti or something similar. We're still holding out for those at the moment, but once we get one in the *Maximum PC* offices, we'll throw it in this beauty and figure out how far we can push it with a (hopefully one day) affordable upgrade.

So in hindsight, what would we upgrade or change? Well, the SSD. 240GB is fine for what this rig is intended to do (in fact you could probably get away with 120GB), but those write speeds leave a lot to be desired. It's not noticeable now, but throw in that extra GPU and a game or two, and the extra write space would be much appreciated. On top of that, cooling is just, okay. The chip sits around the 86 C mark under load in a 23 C office. It could be much better—something extra like a Cooler Master Hyper 212 EVO would placate us.

That said, this thing is a fine little machine. It kicks some serious butt where it counts with its price tag. Throw this together for a relative or your technophobic friends and it'll serve them well for years.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	898	904 (1%)
CrystalDisk QD32 Sequential Read (MB/s)	552	493 (-11%)
CrystalDisk QD32 Sequential Write (MB/s)	533	312 (-41%)
Rise of the Tomb Raider (fps)	6	6 (0%)
Total War: Warhammer II (fps)	6	6 (0%)
3DMark: Fire Strike (Index)	1,233	1,245 (1%)
Price	$561	$387 (31%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero point consists of an Intel Core i3-10100, 8GB of HyperX Savage DDR4 @ 3000 MHz, and a 500GB Samsung 860 Evo 2.5-inch SSD. All tests were performed at 1080p at the highest graphical profile. Historical prices reported at time of writing.

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240GB SSD + 8GB DDR4 memory
Fully benchmarked to today's standards
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IN THE EDIT Get started with Adobe Photoshop PG. 62
BUILD IT!
ULTI
4K G
AMD's latest and greatest compon unshackled
Push your frame to the absolute
16-core, 32-thre Ryzen 9 5950X
Y2K RETROSPECT We take a look back at the Millennium Bug
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Not secure | https://192.168.35.1:9090/system/terminal
GEFORCE GTX
CORSAIR
DELL

```
nickdanp@j5040-itx: ~

 GNU nano 4.8                                              /etc/netplan/
# This is the network config written by 'subiquity'
network:
  ethernets:
    eno1:
      addresses:
      - 192.168.35.1/24
      gateway4: 192.168.35.254
      nameservers:
        addresses:
        - 1.1.1.1
        - 1.0.0.1
        - 1.1.1.1
        - 1.0.0.1
        search: []
  version: 2
  renderer: NetworkManager

                                                              [ Rea
^G Get Help     ^O Write Out    ^W Where Is     ^K Cu
^X Exit         ^R Read File    ^\ Replace      ^U Pa
```

SET UP YOUR OWN NAS SERVER

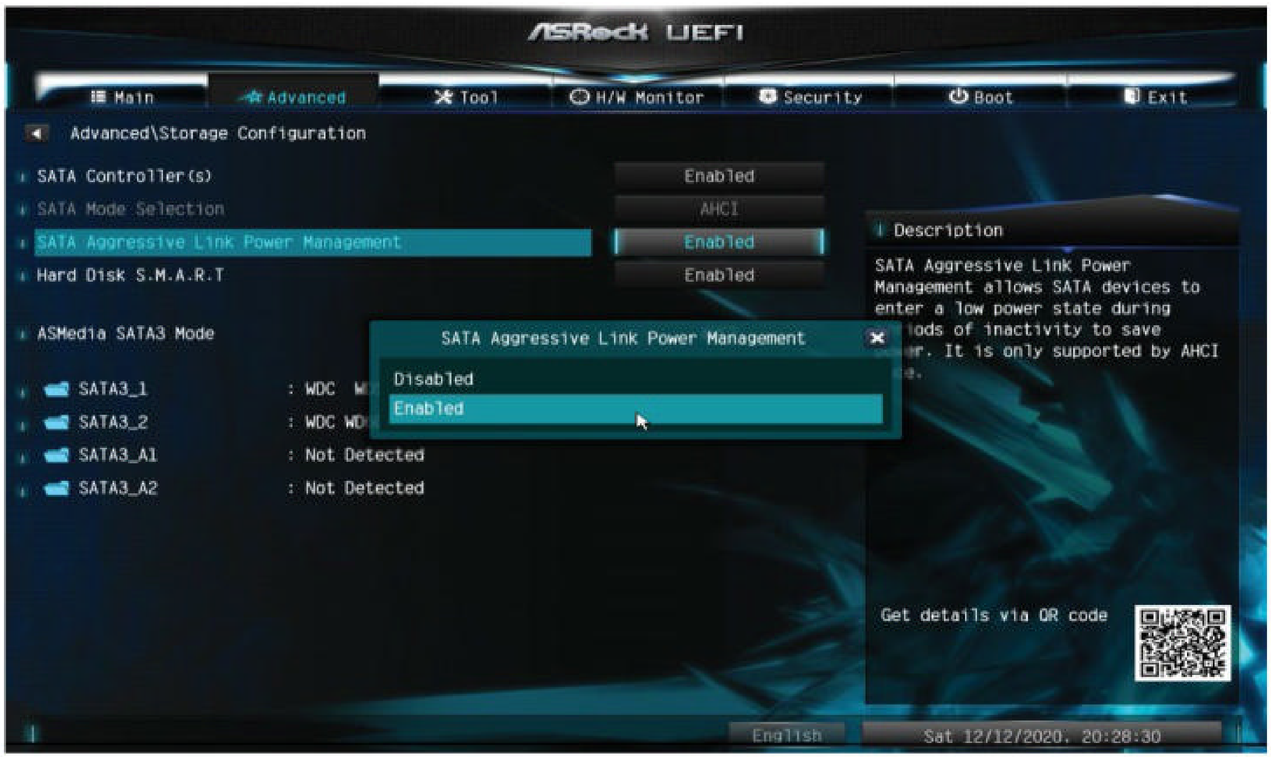
Nick Peers reveals how to build and set up your own custom NAS-beating server

Privileged
Help
Nick Peers
Appearance: Black
Reset
00-installer-config.yaml
16 lines
Justify
To Spell
Cur Pos
Go To Line
Undo
Redo
ASRock UEFI
Main
Advanced
Tool
H/W Monitor
Security
Boot
Exit
Advanced\Storage Configuration
SATA Controller(s)
SATA Mode Selection
SATA Aggressive Link Power Management
Hard Disk S.M.A.R.T
ASMedia SATA3 Mode
SATA3_1
SATA3_2
SATA3_A1
SATA3_A2
Enabled
AHCI
Enabled
Enabled
Not Detected
Not Detected
Disabled
Enabled
Description
SATA Aggressive Link Power Management allows SATA devices to enter a low power state during periods of inactivity to save power. It is only supported by AHCI mode.
Get details via QR code
English
Sat 12/12/2020, 20:28:30
ASUS

Why would you want to build your own NAS server? You can easily pick up a decent off-the-shelf model in the form of a QNAP or Synology NAS, complete with its own operating system, range of apps and all the rest. Why? Because you're a *Maximum PC* reader, do you need any other reason?

Of course not, but we'll give you some anyway. QNAP and Synology are very good at what they do, but you're tied into their ecosystems, which limits you to their choice of hardware, software, and even proprietary filesystems. None of this sits well with us, particularly when our TS-251+ proved so poor at hardware transcoding.

The beauty of the self-build system is that you're in complete control, from choosing the components that make up your turbo-powered NAS, to selecting which operating system powers it. We've hand-picked the best components for a low-powered NAS build, but you're free to use whatever you want—an old PC or laptop will do nicely, or even set one up inside a virtual machine. Our NAS will run Ubuntu Server for maximum flexibility and performance, designed to run headless while remaining accessible and easy to manage via any PC on your local network with a web browser. Ready to get started?



```
Advanced\Storage Configuration

SATA Controller(s)                        Enabled
SATA Mode Selection                       AHCI
SATA Aggressive Link Power Management     Enabled
Hard Disk S.M.A.R.T                       Enabled

ASMedia SATA3 Mode

SATA3_1     : WDC  W
SATA3_2     : WDC WD
SATA3_A1    : Not Detected
SATA3_A2    : Not Detected

SATA Aggressive Link Power Management
Disabled
Enabled

Description
SATA Aggressive Link Power
Management allows SATA devices to
enter a low power state during
 iods of inactivity to save
 er. It is only supported by AHCI
 e.

Sat 12/12/2020, 20:28:30
```

Scour the BIOS for power-efficiency tweaks like this.

First, what hardware will your NAS server be based on? Any PC capable of running Linux is the simple answer. You might have an old PC or laptop gathering dust somewhere looking for a new purpose in life, or perhaps you're looking for an excuse for your next build. The box on the opposite page reveals what we based our server on, which we found very easy to build.

Your NAS server needs a suitable operating system to run, and because it's designed to be run headless, we're going to install Ubuntu Server 20.04 LTS. The Server version doesn't come with unnecessary overheads, including a desktop—everything is done from the command line. Don't worry, though: after it's been set up, we'll install a special add-on (Cockpit) that enables you to easily administer your server remotely from any web browser on your local network. We chose the LTS version to reduce the number of major OS upgrades we'll need to apply during the server's lifetime.

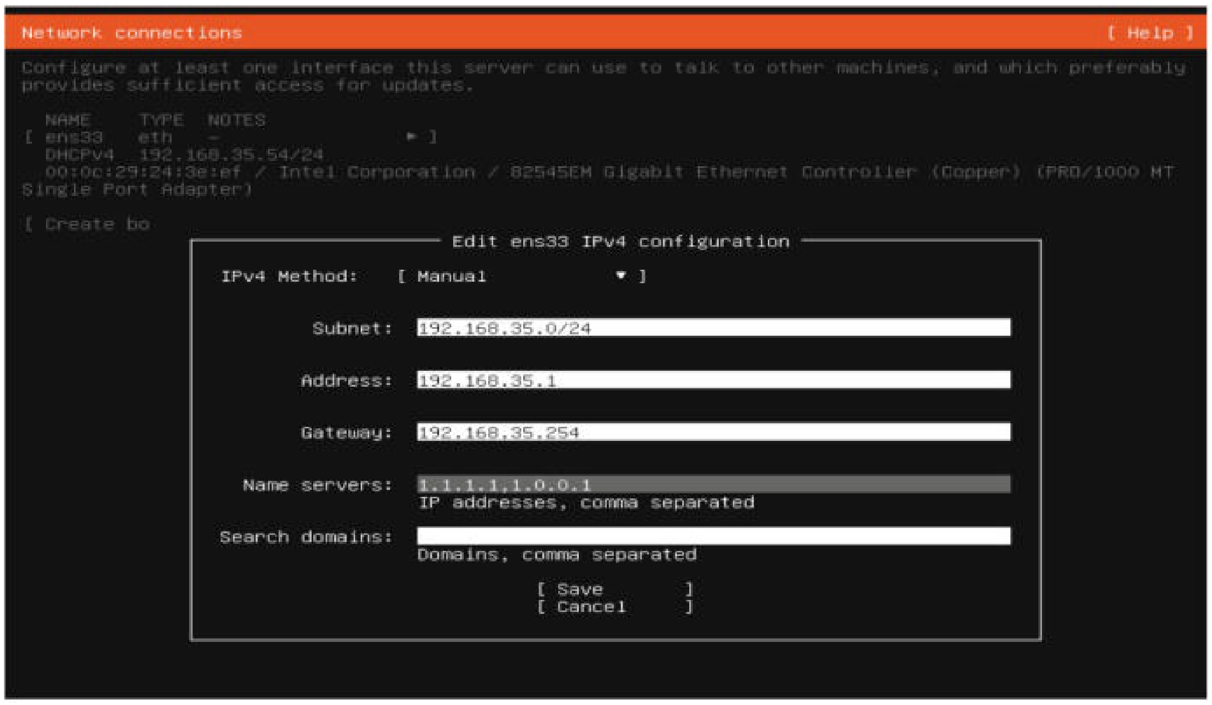
So, once your server's set up and running, you won't need to leave it permanently connected to a monitor or keyboard. That said, it's useful to have access to both resources in case your server loses its network connection. For example, we've got our server tucked away beneath our feet, connected to our main PC's monitor and with the front USB ports easily accessible, should we need to plug in a keyboard.

Start The Install Process

Head over to www.ubuntu.com/download and click the "Ubuntu Server" link, followed by "Option 2 – Manual server installation." You should find the latest LTS version (Ubuntu Server 20.04.2 at the time of writing) as the main option. Click this to download the installation media in ISO format—this will download the amd64 build, which works with regular Intel and AMD processors, including the Pentium Silver J5040.

It's a much smaller download than the full-blown desktop version—a mere 1.1GB. Once downloaded, you can burn it to a blank DVD or use a tool like Rufus (follow the guide at http://bit.ly/MPCubuntuinstall) to copy it to an unused USB flash drive (2GB or larger).

Once you've created your install media, plug it (or insert the disc) into your server PC before powering it on. If you've not already done so, have a quick comb through the BIOS to see if there are any settings you should apply—for example, J5040-ITX users should navigate to "Advanced" and enable "SATA Aggressive Link Power Management" to save energy.



```
Configure at least one interface this server can use to talk to other machines, and which preferably
provides sufficient access for updates.

  NAME    TYPE  NOTES
[ ens33   eth   -              ► ]
  DHCPv4  192.168.35.54/24
  00:0c:29:24:3e:ef / Intel Corporation / 82545EM Gigabit Ethernet Controller (Copper) (PRO/1000 MT
Single Port Adapter)

[ Create bo
            ──────────── Edit ens33 IPv4 configuration ────────────
             IPv4 Method:   [ Manual              ▾ ]

                  Subnet:  192.168.35.0/24

                 Address:  192.168.35.1

                 Gateway:  192.168.35.254

            Name servers:  1.1.1.1,1.0.0.1
                           IP addresses, comma separated

          Search domains:
                           Domains, comma separated

                                   [ Save       ]
                                   [ Cancel     ]
```

Ubuntu Server's text-based install wizard is simple enough.

If the BIOS isn't configured to automatically boot from USB drives, tap the F11 key on startup to bring up the boot menu, then select your USB drive to start the install process. If you're familiar with the Ubuntu Desktop install process, prepare to forget everything—the Server uses a text-based install method.

When the GRUB menu appears, leave "Install Ubuntu Server" selected, and press Enter. You'll see some familiar command-line messages scroll by as your drive is tested for errors and key steps are performed. Eventually you'll be shown the text-based setup menu—not as attractive as Ubuntu Desktop, certainly, but still relatively simple to navigate.

Set Up Your System

Select your preferred language and hit Enter, then choose your keyboard language and layout. The next step is potentially the trickiest, as it involves configuring your network. Servers should be given static IP addresses so they can easily be found on the network, so start by pressing the up arrow key twice to select the current interface (ETH or WLAN) and press Enter. Use the down arrow key to select "Edit IPv4," hit Enter, then hit Enter again to change the setting from "Automatic (DHCP)" to "Manual."

You'll now be asked to set this up, using the down arrow key to move between fields. Ordinarily, you'd expect to enter 255.255.255.0 under "Subnet," but instead type "192.168.x.0/24", substituting "x" with the figure shown under DHCPv4. Enter your desired IP address into the "Address" field—making sure it doesn't clash with other network devices—and your router's IP address into the "Gateway" field.

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"Name servers" is where you enter your chosen DNS servers—typically 8.8.8.8,8.8.4.4 for Google, or 1.1.1.1,1.0.0.1 for Cloudflare. The "Search domains" field is only required if you want to append a local domain to hostnames across your network—for example, "mypc.mydomain.com". If in doubt, leave blank. Once done, select "Save" and hit Enter. Once the changes have been applied, select "Done" and hit Enter. Skip the "Proxy address" field, and leave the default Ubuntu mirror address selected too.

Next, configure your storage. Assuming that the entire boot disk is being given over to Ubuntu, leave "Use an entire disk" selected, along with "Set up this disk as an LVM group" and move on, accepting the filesystem summary (advanced users can select the custom setting to set up separate partitions for root and home directories if they wish). The point of no return comes with the "Confirm destructive action" dialog—select "Continue" to accept these changes.

Next, you'll be prompted to set up your user account—which works in the same way as any Linux/Ubuntu installation—along with your computer's name that will be used to identify it on your network. Next, you'll be given the option of installing OpenSSH for secure remote access to your server via a command-line tool like Putty—not strictly necessary given you'll soon have browser access via Cockpit.

Snap To It

The setup tool will now provide you with a list of optional apps and components you can install via snap (see page 44)—we'd recommend installing Docker and Canonical-livepatch (the latter will ensure you're protected automatically with the latest security patches, without having to manually apply updates or reboot).

When you click "Done," a log screen will appear, revealing that the installation has been preceding in the background and may now be all but complete. Simply wait while security patches are applied, and select "Reboot Now" when it appears as an option. Unplug or remove your install media, and let Ubuntu Server boot.

If all is well, you'll see the usual startup messages appear, then replaced by an option to log into your new install. Enter your username and password to do so. Don't be alarmed if additional messages scroll by—on our test machine, Docker was installed after the first login, along with additional cloud-config configuration.

Once you've booted in, set up your new web-based UI, so you can start running your server headless and switch to what will become your day-to-day user interface: Cockpit. Issue the following commands to get it installed (along with any required updates to existing packages—you'll usually find a dozen or so):

```
$ sudo apt update && sudo apt upgrade
$ sudo apt install cockpit -y
$ sudo systemctl start cockpit
```

Once everything is complete, verify that it's active and running ("sudo systemctl status cockpit"), and if it is, you're now ready to administer your server from any PC on your local network.

Start Using Cockpit

To access your server remotely, browse to https://192.168.x.y:9090/ in any web browser, substituting "192.168.x.y" with the address of your server. You can safely ignore any potential safety risks flagged by your browser—that's because Cockpit generates a self-signed SSL certificate for the IP address. When the security alert appears, follow your browser's advice for creating an exception to allow access (in Firefox, click "Advanced…" followed by "Accept the Risk and Continue,") and you'll be whisked to the login screen.

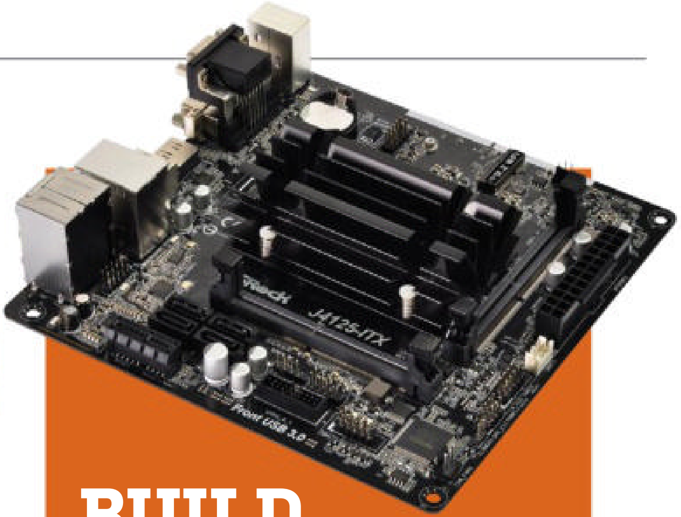
To log into the web interface, enter the same username and password you set up during the install process—in other words, your regular Ubuntu Server login details. Assuming you're on a secure PC, leave "Reuse my password for privileged tasks" ticked, then click "Log In."

You'll find yourself at the main cockpit screen in the "Overview" section, which provides a handy summary of your server's status, as well as a shortcut for shutting down and restarting the system. If you're told you don't have the right to shut down or restart the server, it's because you didn't leave "Reuse my password…" ticked when logging in. Similar elevated functions, such as checking for updates, will also be disabled, and you'll see an "incorrect password attempt" error appear in the system logs, which can be safely ignored.

Elsewhere on this screen, "Health" gives you a quick overview of whether any updates require installing. as well as potential problems (such as services failing to start), while "Usage" lets you monitor your CPU and memory. "System Information" provides a shortcut to an overview of your server hardware, and "Configuration" provides some useful information, plus the ability to change your server's hostname if you so wish.

Fix Cockpit Networking Issues

On the left of the Cockpit window you'll find shortcuts to all the features that Cockpit offers. Before going further, however, the Networking and Software Updates aren't



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BUILD YOUR OWN NAS

If you're looking to build your own NAS from scratch, then there are two key considerations: chassis size, and power draw. A NAS is designed to be run 24-7, so a low-powered CPU like Intel's Atom range seems a logical choice. But if you want to use your NAS as a Plex or Jellyfin media server, you need a processor with decent hardware transcoding support. This is where Intel's Pentium Silver J5040 chip comes into its own: quad-core, with onboard Intel UDH Graphic 605 ensures that the hardware transcoding produces watchable streams, while its miniscule power draw means the chip can be cooled by heatsink alone.

Our server was built around the ASRock J5040-ITX motherboard (pictured above), which comes with the J5040 chip onboard with heatsink. It technically supports up to 8GB RAM, but we successfully installed 16GB, and comes with four SATA ports, one PCIe slot (to which we added a further two SATA ports), and plenty of USB connectors too. We paired this with an InWin IW-MS04 server case ($133.49 from www.newegg.com)—it has four removable drive bays, plus two internal drive slots, and we placed our 1TB WD Red SSD drive into one of these for running the OS and key services. We then populated two of the four drive bays with existing 6TB and 3TB WD Red drives, which is where our data files—including media collection—is stored.

The build was relatively simple, and we'll be showcasing this in a future issue.

SNAPS VS REPOS

Traditionally, software is installed on Ubuntu via package archives known as repositories, and these remain a vital tool for getting software onto your server. Ubuntu provides three official repos by default for Ubuntu 20.04 LTS: focal, focal, focal-updates, and focal-backports. You can browse their contents at https://packages.ubuntu.com, and these can all be installed from the command line as soon as you log into Ubuntu Server for the first time.

The biggest issue with Ubuntu's package archives is that many applications found here are frozen at the point of Ubuntu 20.04's release, so any subsequent developer updates are ignored until your next major upgrade (22.04 isn't due until May 2022). One prime example of this is Cockpit, which is 'stuck' at version 215 in Ubuntu 20.04 (27 updates have been released since then).

Many applications offer their own repositories, which work in the same way as Ubuntu's own: once installed, they're accessible via the "apt" command, and whenever new updates are released, you'll be informed of them via Software Updates. Muddying the waters further, Ubuntu's developer Canonical has developed "snaps," which are installed using the "snap" command. Once in place, snaps then update automatically as soon as the developer releases a new version.

Apps can exist in multiple repos as well as snap—if an app exists as a snap (use the "snap find appname" command to verify if it does), then installing through here rather than the focal repos will ensure your apps remain up to date. If they're not on snap, visit the software's website to see if it provides its own repo. Add this as instructed, then use "apt" in the usual way to install the package.

configured correctly in Ubuntu 20.04, so we'll need to edit a configuration file, and reboot to fix the problem and make Cockpit fully functional.

To do this, select the Terminal shortcut, which works just as it does in Ubuntu itself. There's Tab autocomplete to speed up path and filename entries, and it's fully compatible with the clipboard too, making it easy to copy and paste commands from elsewhere, including webpages. In the Terminal, type the following command:

```
$ sudo nano /etc/netplan/00-installer-config.yaml
```

This will open a configuration file. Add the following line beneath "version: 2":

```
renderer: NetworkManager
```

Press Ctrl + X followed by Y, and Enter to save your changes. Reboot your server.

Complete The Cockpit Tour

Once you've logged back in, pick up where you left off. "Dashboard" links to performance-related graphs (also accessible elsewhere in Cockpit, which is why the feature's been removed from later builds), while "Host" houses shortcuts to all the parts of your system you can control via Cockpit.

"Logs" provides you with a handy look at your system logs, while "Storage" gives you both an overview of any drives connected to your PC, as well as the tools for formatting and mounting them (more on that shortly). "Networking" works in a similar way—not only can you monitor your network connection, but you can configure additional networking interfaces, plus make changes to your main interface by rolling over it under "Interfaces" (it should turn blue), and then clicking it. From here, click the IPv4 entry to make your changes.

"Accounts" enables you to view, modify and add new accounts to your system, with options to force regular password changes, as well as adding authorized public SSH keys. You can also forcibly disconnect other users who are logged on to Cockpit from here, by clicking the user followed by "Terminate Session."

"Services" gives you an overview of all the various background processes running on your system, and you also gain the ability to manually stop, start and auto-start them from here. The "Applications" section is where any plugin modules that extend Cockpit's functionality can be found—by default, only "Storage" is set up. This is where the Docker plugin will appear when we add it later.

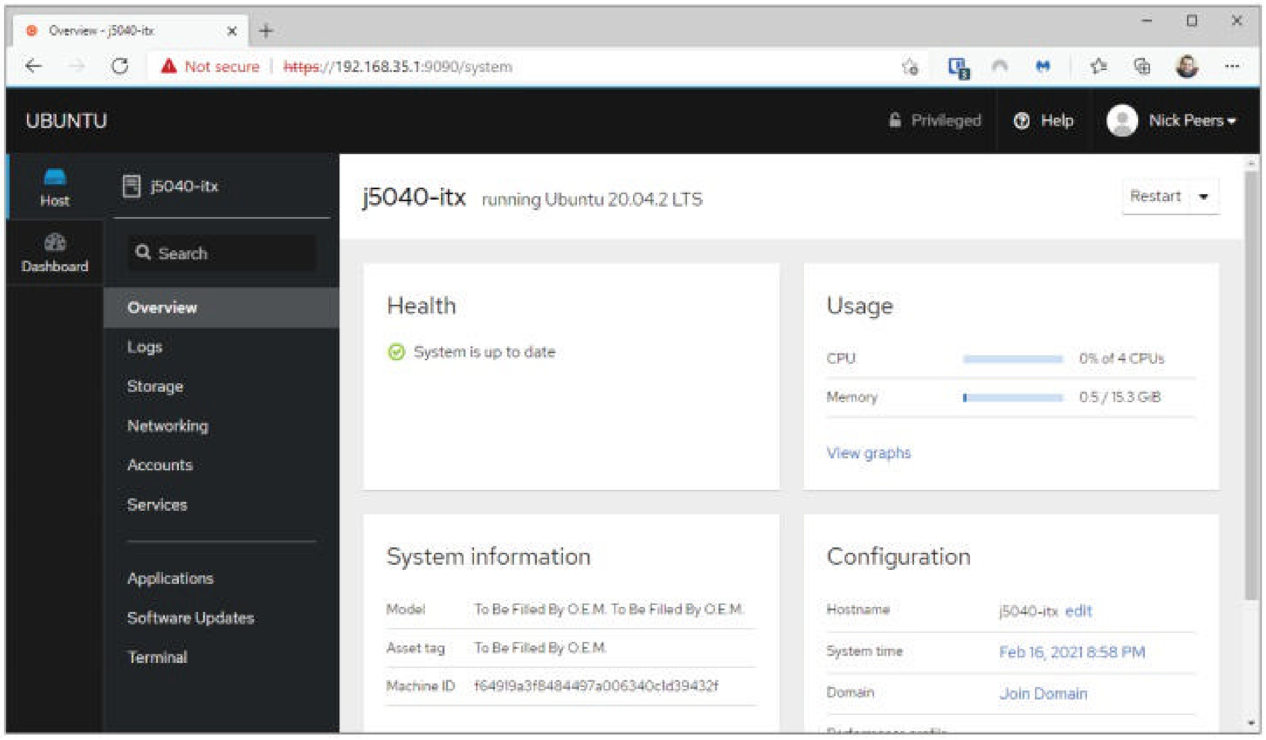
Last is "Software Updates," a convenient place to check for, apply, and review previous updates to your system now that it works correctly.

Configure Your Storage

Now you've got Ubuntu Server and Cockpit up and running on your main boot drive, it's time to configure the additional drives you've physically installed. Before doing so, however, let's take a few precautions and instigate a robust backup system—see the box opposite for details.

Once done, return to configuring your drives. It's a relatively straightforward process, but it does assume that you have a working knowledge of how Linux views drives and partitions—namely, they're mounted as folders within your filesystem, hence the need to set what are known as mount points.

Before going any further, you need to create these directories. To keep things simple, we suggest housing the links within your own personal home directory



j5040-itx running Ubuntu 20.04.2 LTS

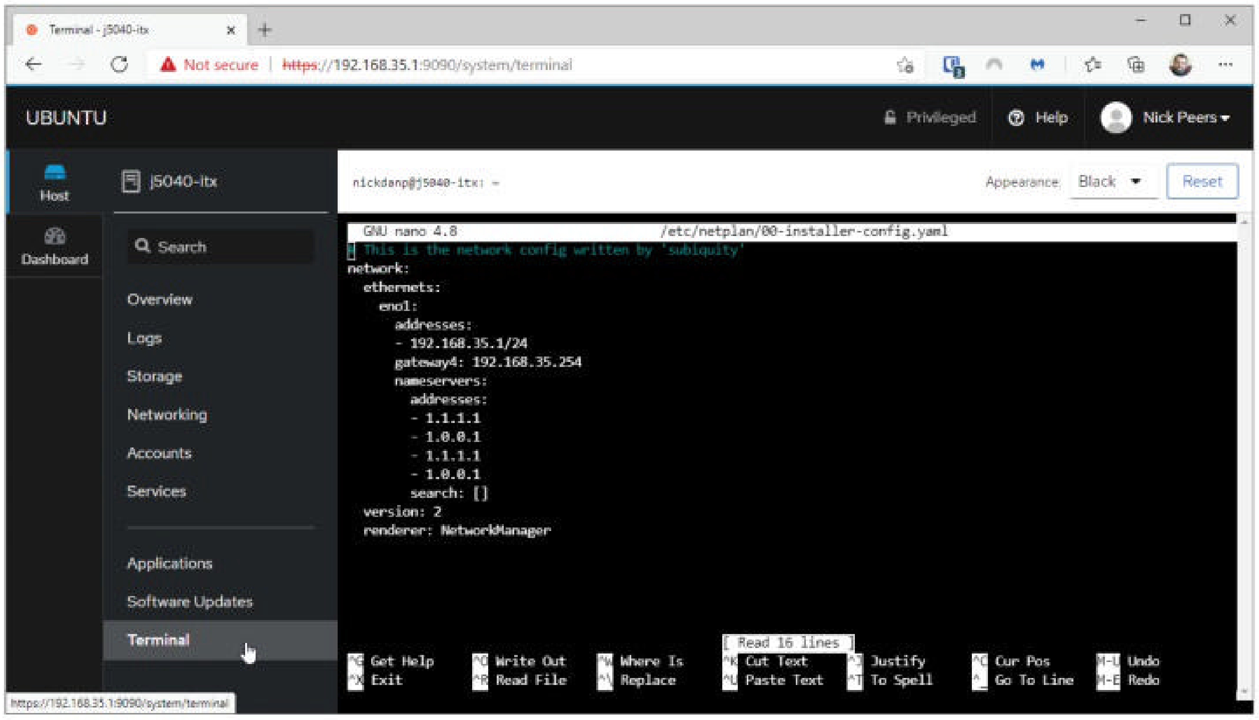
System is up to date

CPU 0% of 4 CPUs
Memory 0.5 / 15.3 GiB

Model To Be Filled By O.E.M. To Be Filled By O.E.M.
Asset tag To Be Filled By O.E.M.
Machine ID f64919a3f8484497a006340c1d39432f

Hostname j5040-itx edit
System time Feb 16, 2021 8:58 PM
Domain Join Domain

The main Cockpit view provides a handy system overview.



```
  GNU nano 4.8                  /etc/netplan/00-installer-config.yaml
# This is the network config written by 'subiquity'
network:
  ethernets:
    eno1:
      addresses:
      - 192.168.35.1/24
      gateway4: 192.168.35.254
      nameservers:
        addresses:
        - 1.1.1.1
        - 1.0.0.1
        - 1.1.1.1
        - 1.0.0.1
        search: []
  version: 2
  renderer: NetworkManager

                                  [ Read 16 lines ]
^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify     ^C Cur Pos     M-U Undo
^X Exit        ^R Read File   ^\ Replace     ^U Paste Text  ^T To Spell    ^_ Go To Line  M-E Redo
```

Add this line to ensure Cockpit plays nicely with Ubuntu 20.04.

to avoid permissions issues. Open the Terminal and enter the following:

```
$ mkdir ~/media
$ mkdir ~/media/bay1
```

You're now ready to partition, format, and mount your first drive. Switch to the "Storage" section, and scroll down to the "Drives" section, which lists all the physical drives you've installed—note, we're assuming they're currently unformatted. /dev/sda refers to your boot drive, which you obviously set up during installation, so move on to /dev/sdb, which you should be able to confirm is the correct drive by its capacity. Click this to access its own properties screen, where you'll see that it's listed as "unrecognized data" under "Content." To fix this, click "Create Partition Table," choose your partition type (MBR or GPT, leave the latter selected if unsure) and click "Format."

With the basic partition table in place, click "Create Partition" to open a new dialog that makes it easy to partition the drive as you see fit, using the slider if necessary to create multiple partitions on the same drive, one after the other. We recommend you select ext4 as your file type rather than the recommended xfs, which is geared more towardsenterprise-class OSes, such as Red Hat.

Give your drive a suitable name—consider naming it for the mount point you created earlier (such as Bay1)—and then enter the path to the mount point —/home/←username→/media/bay1. You'll see options for read-only mounts and custom mount options, but leave "Mount now" ticked, before clicking "Create Partition" and waiting for the process to finish (it can take a little while).

Once complete, you may see a warning sign next to the drive—if this happens, click the warning, and choose to mount now, which should complete the job and permanently give you access to the drive and its contents via your chosen mount point. If you have more drives installed, repeat the process for each drive—/dev/sdc, /dev/sdd, and so on.

Set Up Folder Sharing

Next, it's time to configure your shared folders. To ensure that you can access them from any OS, you'll need to install Samba. The following sets up both Samba and a shared folder inside your newly formatted hard drive:

```
$ sudo apt install samba
$ mkdir ~/media/bay1/shared
$ sudo nano /etc/samba/smb.conf
```

Add the following code block to the bottom of the file (don't forget to substitute <username> with your username):

```
[shared]
    comment = Ubuntu Shared
    path = /home/<username>/media/
bay1/shared
    read only = no
    browsable = yes
```

Save the file, exit Samba, and issue the following two commands:

```
$ sudo service smbd restart && sudo
ufw allow samba
```

Finally, assign a special Samba password to your user account to gain access to the shared folder from other computers (make sure it's different to your system password for obvious reasons):

```
$ sudo smbpasswd -a <username>
```

You should now be able to access the shared folders from other devices on your network using the username and password you just configured. If they don't show up automatically, type \\192.168.x.y (substituting "192.168.x.y" with your

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BACK UP YOUR SYSTEM

We're sticklers for backing up on *Maximum PC*, so we're not going to let you off the hook. Every now and then you might want to try something on your server that either fails to work or breaks something else in the process. Thanks to timeshift you can roll things back, just like Windows' System Restore:

```
$ sudo add-apt-repository
ppa:teejee2008/timeshift
```

```
$ sudo apt update && sudo apt
install timeshift
```

Type "timeshift" after installing to get a rundown of all available commands, but the following will perform your first backup, which will be stored your boot partition:

```
$ sudo timeshift --create --comments
"A new backup"
```

Scheduling backups from the command line is tricky—you'll need some working knowledge of crontab—but it's easy enough to run manually on demand, such as before major updates or installations. Then, should you ever need to restore a backup, simply issue the following command:

```
$ sudo timeshift --restore
```

You'll be prompted to choose which backup to roll back to (which is where the comments come in handy), and whether to reinstall the GRUB bootloader. One reboot later, and your changes will have magically vanished.

If you'd prefer to administer your backup from your browser, then examine BorgBackup (https://borgbackup.readthedocs.io/) as an alternative. It's quite a lot more fiddly to set up, but the final results should be worth it in the end.

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server's IP address) into a Folder Explorer window to manually access the shares.

Moving Forward With Your New Server

The basics are in place. Now you're ready to have fun. Start by installing the packages you need to deliver the services you require. If you want to quickly and easily transfer data from elsewhere on your network (such as a gigantic folder of media files) without opening up any shared folders, why not use a sync tool like Syncthing (https://syncthing.net/downloads/) to do the hard work for you?

When it comes to setting up your media server, both Plex and Jellyfin are good choices, and should be installed directly onto your server via their respective repositories, so you can take full advantage of hardware transcoding to relieve the burden on your server. For more on the various ways of getting up-to-date software on to your server, check the box "Snaps versus repos" on page 44.

Work With Docker

Some services are best run in their own isolated environments for security and stability reasons. That way, if the service runs into a problem, it can't bring down your entire system. One way to do this would be to set up multiple virtual machines, but setting up a dedicated VM with its own operating system and overheads is an impractical (never mind wasteful) use of your server's fairly limited resources.

An alternative approach is to use what are known as "containers," which can be thought of as "thin" VMs that contain only the bare requirements—dependencies, configuration files and so on—needed to run the service in question. The best-known implementation for containers is Docker, and that's what we're using in this feature (see the "Docker versus Podman" box for why Docker is no longer officially supported by Cockpit, and the reasons why we're sticking with it for now).

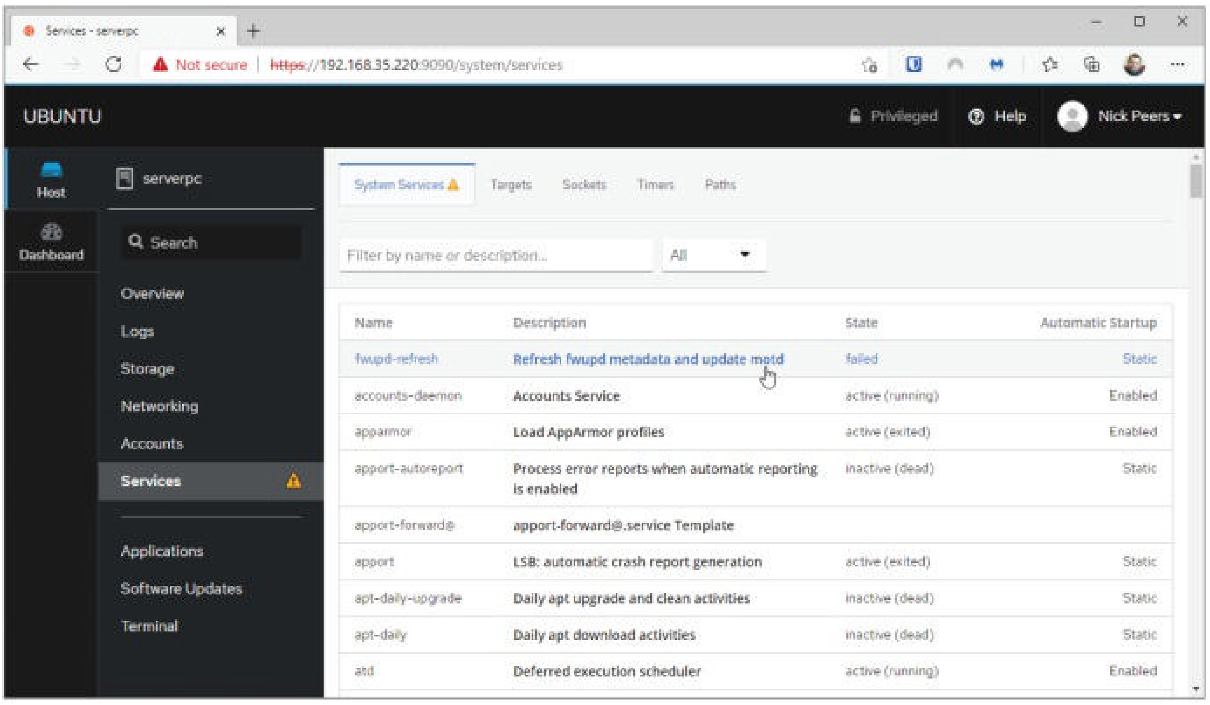
While Docker-cockpit is no longer officially supported, it still works fine. Here's what you need to do to obtain and install it:

```
$ wget https://launchpad.net/ubuntu/+source/cockpit/215-1~ubuntu19.10.1/+build/18889196/+files/cockpit-docker_215-1~ubuntu19.10.1_all.deb
$ sudo apt install ./cockpit-docker_215-1~ubuntu19.10.1_all.deb
```

Once installed, log out and back into Cockpit, and you'll see a new option—"Docker Containers"—appear on the left of the screen. Select this, and you'll discover the joys of running and managing containers without having to get tangled up in the command line. And unlike frustrating experiments with Podman, it works straight off the bat too.

You'll also see a new option appear under "Accounts" when you click on your user account: "Container Administrator." This basically adds the selected user to the "Docker" group to let them run Docker from the command line without requiring the use of "sudo.")

Now that you've set up the fundamental parts of your NAS server, take another timeshift backup. Once that's done, you're ready to get on with making the most of it. How about starting with some Docker containers? Don't know where to start? We'll reveal how to add a host of useful services, from password manager and reverse proxy to audiobook streaming server, next issue.⏻



Name	Description	State	Automatic Startup
fwupd-refresh	Refresh fwupd metadata and update motd	failed	Static
accounts-daemon	Accounts Service	active (running)	Enabled
apparmor	Load AppArmor profiles	active (exited)	Enabled
apport-autoreport	Process error reports when automatic reporting is enabled	inactive (dead)	Static
apport-forward@	apport-forward@.service Template		
apport	LSB: automatic crash report generation	active (exited)	Static
apt-daily-upgrade	Daily apt upgrade and clean activities	inactive (dead)	Static
apt-daily	Daily apt download activities	inactive (dead)	Static
atd	Deferred execution scheduler	active (running)	Enabled

It's no longer officially supported, but Docker-cockpit still works a treat.

© UBUNTU, DOCKER, PODMAN

DOCKER vs PODMAN

When Cockpit was first developed, it had plug-in support for administering your Docker containers remotely via its user-friendly web interface. But then Red Hat OS became a major backer of Cockpit, and when Red Hat developed its own alternative to Docker—Podman—the developers were quick to drop official support for Docker in favor of Podman.

Podman and Docker both support the same container types, and Podman uses the same command structure as Docker—indeed, Red Hat recommends the "alias docker=podman" command to minimize disruption when switching from Docker to Podman. Podman has two key advantages: each container runs within its own self-contained process; and it supports "rootless" containers, namely containers that can be run using non-root user accounts for greater security.

Given this, you'd expect us to embrace Podman fully in this tutorial. And that's what we intended to do. But Podman is still relatively young, and major releases keep breaking functionality, particularly on lesser supported distros like Ubuntu. At the time of writing, Podman's rootless support is hit and miss in Ubuntu—and that's being generous.

Thankfully, while Cockpit's developers have dropped support for Docker, you can still install the plug-in manually. So that's what we've decided to do for this feature: we're going to stick with Docker, and give Podman time to develop further and iron out its teething problems. And don't worry about missing out on Podman's rootless support —you can configure Docker containers to run using a specific user account with just two environment variables (see https://docs.linuxserver.io/ for more details).

TECH PORN

PERFORMANCE GEAR LAID BARE

1 SCREEN DOMINANCE

The Aorus 15G XC comes with a 15-inch 1080p "IPS-like" screen, capable of hitting a staggering 240Hz refresh rate, putting that GPU to work. That's a pixel density of 146.86 PPI—more than you get from a 32-inch 4K panel.

2 DESIGN DECISIONS

Whether it's the super-slim bezels, the slick chiclet keyboard, or the no-frills aesthetic language throughout the build, Gigabyte's Aorus 15G really does tick all the right boxes.

3 PROCESSING UNLOCKED

Eight cores, 16 threads, and a 5GHz clock speed are baked into this 14nm Comet Lake beast from Intel. That's some serious grunt from a chip, although we'd expect no less from such a mature architecture.

Gigabyte Aorus 15G XC

FOR WHAT FELT LIKE an eternity, each generation and advancement of GPU architecture signalled a shift in processing power. For the longest time that power was levied almost exclusively at dedicated graphics cards, ripe and ready to rip those frame rates into submission within the confines of their glorious metal towers. With each of those steps forward, we saw mobile processors hewed from the same architectural rock—but although impressive, they were never quite within reach of the same monumental heights. For years this was the case, until the 10th generation of Nvidia GeForce cards rewrote the rulebook, and incorporated fully fledged graphics processors of the same name and sku into the mobile gaming notebooks that dominated the marketplace.

However, there was a problem: heat. And thus was introduced the Max-Q line of mobile graphics processors—slightly declocked, power-sensitive variants of the same graphics cards that the desktop market was privy to, with only minor losses in overall performance.

It's been three generations since the introduction of Max-Q tech, and it's come a long way. With the latest RTX series of cards launching, we're once again witness to a new generation of mobile GPUs making its way into the greatest laptops of the day, not least the Aorus 15G XC, complete with RTX 3070, 32GB of DDR4, and eight-core, 16-thread Intel Core i7-10870H processor. **–ZAK STOREY**

© GETTY IMAGES

WI-FI 6E THE 6GHZ REVOLUTION

It's not just humans that are hungry for more wireless bandwidth. A 15-billion-strong army of interconnected machines wants in on the action, too. Luckily, Wi-Fi 6E has every single one of them covered. *Jeremy Laird* explains

ACCORDING to recent research by networking specialist Cisco, nearly two-thirds of the global population will have internet access by 2023. That's around 5.3 billion souls, a huge leap from the 3.9 billion that had access in 2018.

But here's the kicker. Wireless network growth is expected to be even more explosive. Cisco reckons that there were 169 million wireless hotspots globally in 2018, but the number is set to quadruple to 628 million by 2023. That's a whole lot of new Wi-Fi.

Of course, it's not just humans that are bandwidth hungry. In 2018 there were around 5 billion connected devices that fell into the M2M, or machine-to-machine, connectivity category. In other words, machines talking to each other with no humans involved. In 2023, the number of connected M2M devices is expected to be a colossal 14.7 billion.

The result is a staggering, almost incomprehensible demand for wireless bandwidth. And that's a problem. Anecdotally, anyone who lives in a town or city will be all too familiar with the scroll-inducing litany of options available any time the airwaves are sampled for a list of local wireless networks.

More empirically speaking, there are ever more devices and access points competing for the same relatively narrow wireless airspace. Until now, that is. Because 2021 is the year of Wi-Fi 6E, the biggest step change in wireless technology ever, and the solution, very probably, to the looming wireless connectivity crunch.

WHERE DO WE BEGIN?

Billions of new users, tens of billions more devices, most of them wirelessly connected—this is the near future of the internet, and it's incredibly exciting. But it's also a major technological headache. The central problem is airspace. It's over 15 years since the last significant chunk of spectrum was freed up for wireless networking use.

That's right, we're still using the same airspace today as we were when smartphones were barely a thing. At least, that was true until now, thanks to Wi-Fi 6E. In April last year, the Federal Communications Commission took the momentous step of opening up a huge swathe of bandwidth for unlicensed Wi-Fi use. This year, the first Wi-Fi 6E devices designed to use that epic chunk of new spectrum are coming online.

"This is the most monumental decision around [the] Wi-Fi spectrum in its history, in the 20 years we've been around," said Kevin Robinson of the Wi-Fi Alliance, the industry group overseeing the implementation of Wi-Fi. In one fell swoop, the FCC's decision literally quadruples the amount of airspace available to Wi-Fi networking. The new spectrum has enough room for up to seven simultaneous maximum-capacity Wi-Fi streams, with no interference and without using any existing airspace.

In dispassionate terms, more bandwidth, lower latency, and increased capacity are the immediate technical benefits, with touted applications ranging from whole home gigabit coverage, multi-gigabit Wi-Fi venue capacity, high-speed tethering, low-latency Wi-Fi calling, next-gen VR and AR experiences, and more. But we're getting ahead of ourselves. First we need to get under the hood of Wi-Fi 6E.

In most regards Wi-Fi 6E is merely an extension of the existing Wi-Fi 6 standard. Indeed, the "E" in Wi-Fi 6E stands for "extended"—in this case extended into new airspace, specifically the 6GHz band. Previous Wi-Fi standards have operated in the 2.4GHz and 5GHz ranges.

Prior to that FCC decision, a total of 400MHz of usable space across those two bands has been available for unlicensed Wi-Fi devices. Wi-Fi 6E? It has access to the entire 6GHz band, and then some. The new airspace spans a huge 1,200MHz range from just below 6GHz to a little above 7GHz. In really simple terms, this new spectrum provides far more Wi-Fi capacity than all previous bands combined. It's a dramatic addition.

However, that doesn't mean that Wi-Fi 6E will automatically translate into higher peak speeds or devices. Like standard Wi-Fi 6, Wi-Fi 6E tops out at 9.6Gbps. But that's a theoretical figure, not something you'll get in the real world. Apart from anything else, there are few if any internet applications that supply that kind of bandwidth. Instead, what Wi-Fi 6 is about isn't really top speeds, but improving performance in the context of high densities of access points and devices.

Peak speeds for individual devices are actually likely to improve with Wi-Fi 6E. You can expect real-world speeds of around 2Gbps, which is pretty spectacular. Partly that's down to the inherent advantages of the 6GHz band over 5GHz and 2.4GHz, but it's mostly a function of reduced interference and less congested airspace. Early Wi-Fi 6E devices in particular will have the 6GHz band to themselves, making multi-gigabit speeds a reality, rather than a claimed specification you're never likely to achieve.

But rather than hitting the kind of multi-gigabit performance that few users really need, it will be improved reliability in a multi-device environment where Wi-Fi 6E truly delivers. Being able to reliably get the most out of that 300Mbps fibre connection, for instance, or support zillions of access points and devices in densely populated urban areas while maintaining decent speeds, is what Wi-Fi 6E will be really good at.

Vbit AX210S

A desktop PCIe 6E board can bring the new Wi-FI 6E to your PCs.

When Wi-Fi 5 (previously known as 802.11ac) came out in 2013, the average US household had around five Wi-Fi devices. Today, it's around 10, and most estimates predict that number to continue increasing. Imagine all those devices in an apartment building, battling for limited airspace that was defined decades ago.

Maintaining speedy Wi-Fi performance in built-up areas, with noisy airwaves full of devices, is already hard. Without the new spectrum, the anticipated uptick in

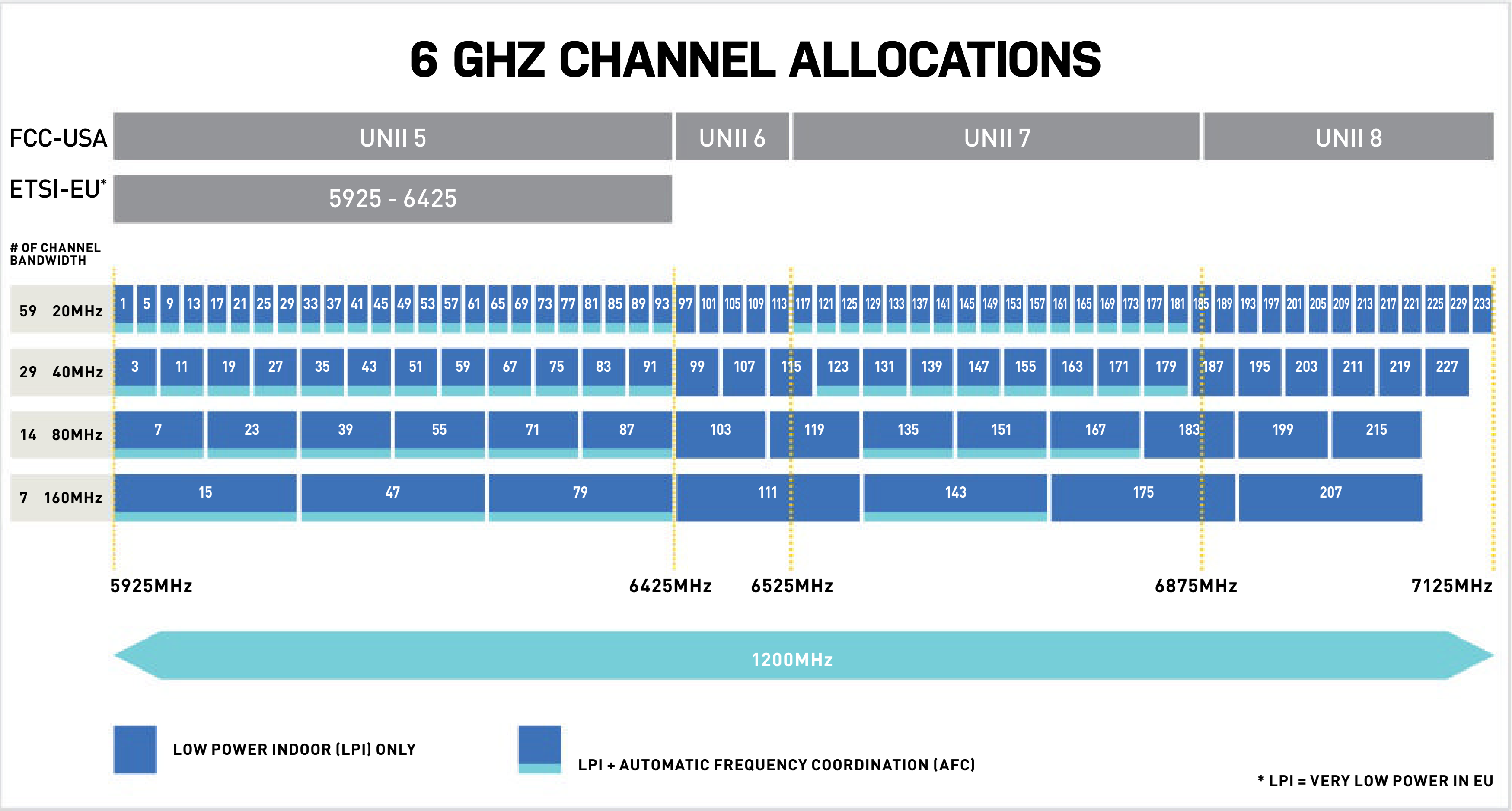
WI-FI 6E AROUND THE WORLD
WHAT'S HAPPENING OVERSEAS?

Global momentum behind Wi-Fi 6E is building fast. A number of countries and territories have released or are preparing to release the 6GHz spectrum. The UK, Chile, South Korea, and the United Arab Emirates are on the list of early adopters who have already freed up airspace. Meanwhile, the likes of Brazil, Canada, Mexico, Peru, Taiwan, Japan, Saudi Arabia, Myanmar, and Jordan have begun the process of allocating spectrum.

However, not all Wi-Fi 6E implementations will be equal. For instance, the UK's regulatory body Ofcom has only unlocked 500MHz of new spectrum, specifically 5,925MHz to 6,425MHz. By most measures, that's a large swathe of new airspace. The new spectrum is enough for three new 160MHz Wi-Fi channels, or as many as 24 new 20MHz Wi-Fi channels. But it's a far cry from the 1,200MHz of extra space in the US.

As for countries that have unleashed the full 1,200MHz of spectrum, the second after the US was South Korea. In October last year, South Korea approved 1.2GHz of spectrum from 5,925MHz to 7,125MHz range for unlicensed Wi-Fi use. Soon after Chile became the third country globally and the first in South America to release the full 6GHz band for Wi-Fi 6E.

© VBIT


6 GHZ CHANNEL ALLOCATIONS
FCC-USA
UNII 5
UNII 6
UNII 7
UNII 8
ETSI-EU*
5925 - 6425
# OF CHANNEL BANDWIDTH
59 20MHz
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101 105 109 113 117 121 125 129 133 137 141 145 149 153 157 161 165 169 173 177 181 185 189 193 197 201 205 209 213 217 221 225 229 233
29 40MHz
3 11 19 27 35 43 51 59 67 75 83 91 99 107 115 123 131 139 147 155 163 171 179 187 195 203 211 219 227
14 80MHz
7 23 39 55 71 87 103 119 135 151 167 183 199 215
7 160MHz
15 47 79 111 143 175 207
5925MHz
6425MHz
6525MHz
6875MHz
7125MHz
1200MHz
LOW POWER INDOOR (LPI) ONLY
LPI + AUTOMATIC FREQUENCY COORDINATION (AFC)
* LPI = VERY LOW POWER IN EU

WiFi 6E opens up a tremendous amount of bandwidth.

WHERE ARE ALL THE WI-FI 6E DEVICES?

GET READY FOR THE 6GHZ ARMY

In December 2020, the FCC certified the first Wi-Fi 6E device, a low-power indoor transmitter from Broadcom. By the end of this year, well over 300 million Wi-Fi 6E devices are expected to enter the market.

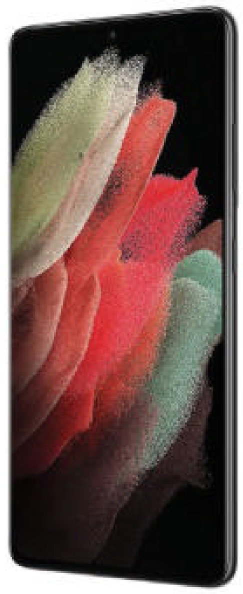
Inevitably, most of the big brands in wireless are already on board, including Broadcom, Qualcomm, Intel, Samsung, and Netgear. The first Wi-Fi 6E smartphone is the new Samsung Galaxy S21 Ultra. The new handset's Wi-Fi 6E connectivity is powered by technology from none other than Broadcom.

With no fewer than seven Wi-Fi and Bluetooth radios, including support for dual Wi-Fi 6E streams, the Galaxy S21 Ultra is a glimpse into the future of handheld Wi-Fi, capable of around 2Gbps of peak wireless performance along with claimed latency of just a few milliseconds. It can operate across the full Wi-Fi spectrum, including the 2.4Ghz band and all the way from 5.1GHz to 7.125GHz. The Galaxy S21 Ultra also supports all the key Wi-Fi 6E technologies, including super-wide 160MHz channels and MU-MIMO.

Meanwhile, at CES several companies including Netgear, TP-Link, Linksys, and Asus announced Wi-Fi 6E hardware, including routers and mesh systems. The fastest of the lot, at least by the claimed numbers, is the Asus ROG Rapture GT-AXE11000, which is said to be good for 11Gbps. While we doubt you'll see that in the real world, we suspect Wi-Fi 6E kit will get closer to the theoretical maximums than previous wireless kit.

As for device adapters, we haven't seen any Wi-Fi 6E USB dongles yet. But a number of PCIe add-in boards for desktops are available. Intel's Wi-Fi 6E AX210 M.2 card will add Wi-Fi 6E to laptops for a piffling $32.

It looks like an escapee from the *Mandalorian*, but the Netgear RAXE500 was one of the very first 6GHz routers.



Samsung was first out of the gate with a 6GHz Wi-Fi 6E smartphone in the Galaxy S21 Ultra.

Asus's ROG Rapture GT-AXE11000 is the fastest Wi-Fi 6E router yet, with a claimed peak performance of 11Gbps.

© NETGEAR, SAMSUNG, ASUS

Wi-Fi-connected devices would make a bad situation worse, which is where Wi-Fi 6E's huge new airspace will really deliver.

HOW DOES IT WORK?

So that's the broad brush of how Wi-Fi 6E is going to free up capacity, but it's worth digging one layer deeper into the details of how wireless networking works, to understand the mechanics of just how limited the spectrum has been so far, and why the 6GHz band is such a big deal.

At the core of it all are channels, the portions of spectrum over which wireless devices transmit. The 2.4GHz spectrum has 11 channels, each 20MHz wide. However, only three of those channels do not overlap. The 5GHz band ups that to 24 non-overlapping 20MHz channels. That's the basic channel structure. However, multiple channels can also be combined to create a single, wider channel. If you think of channels as physical highways, it's a bit like adding lanes to increase traffic capacity, or in this case data throughput. Remember those impressive peak speeds quoted by Wi-Fi router makers? They're typically achieved using wider channels.

Anyway, the 2.4GHz band supports 20MHz and 40MHz channel widths, while the 5GHz band also supports 80MHz and 160MHz channels. We'll come to the channel structure of Wi-Fi 6E in a moment. So, when a device on a Wi-Fi network wants to transmit, it must wait for the channel on which it is operating to be clear. Only one device can transmit at a time.

There are mitigating technologies designed to enable a certain amount of parallel device transmission on a given channel, such as MU-MIMO, or "multi-user, multiple input, multiple output." However, where overlapping channels are in use, devices on one channel will transmit regardless of the traffic on the other overlapping channels, causing interference and performance degradation. This is known as "adjacent-channel interference" (ACI).

The other type of interference happens when the coverage area of a wireless access point, known as a cell, overlaps with that of another access point running on the same channel. Known as "co-channel interference" (CCI), this creates a single, larger cell that forces any device in the combined cell to wait in turn for the channel to become clear before transmitting. Imagine an access point in a next-door apartment running on the same channel as yours. In terms of network contention, any devices connected to the neighboring access point may as well be connected to yours.

As for how all this applies to the real world, well, in theory wider channels deliver more bandwidth. If you're running a single access point and you don't have any neighbors or other sources of wireless contention, setting your access point to operate over the widest possible channel will give the best performance. Most people, of course, live in built-up areas with numerous nearby wireless networks. In that context, a wide channel is almost guaranteed to overlap with nearby networks and suffer interference. A smaller channel with less overlap and therefore reduced interference can actually deliver better performance.

Now you've got your head around all that, how does Wi-Fi 6E fit in? For starters, it has enough spectrum for 59 fully non-overlapping 20MHz channels. So, the odds of suffering significant interference on a 20MHz channel will be very low for most users. At the other end of the scale, there's space for seven of the highest bandwidth 160MHz channels. Add in existing 2.4GHz and 5GHz channels, and even in a fairly busy urban area Wi-Fi 6E users will have a fighting chance of achieving something like the claimed maximum performance figures—which until now were really only relevant for marketing purposes. At the very least that will be true for the first few

6E AND 5G
WIRELESS FRENEMIES

According to some quarters, Wi-Fi 6 and by extension its Wi-Fi 6E cousin will be replaced by 5G cellular technology before they've had a chance to take off. And there's at least some substance behind that narrative.

Historically, cellular networks have been wide-area solutions working at long distance both indoors and out. Meanwhile, Wi-Fi is a short-range technology primarily used indoors. However, with 5G comes a greater use of so-called small-cell access nodes designed to operate over shorter ranges and support fewer devices. That sounds a lot like Wi-Fi. What's more, mid-band 5G networks also operate on similar 2.5GHz and 3.5GHz frequencies to Wi-Fi.

But realistically, you can't put a SIM in every device. 5G networks are also typically installed by telco firms, use specific licensed spectrum, and require fees for access. None of that is a good fit for home or office users installing their own networks.

What's more, data ownership is a major impediment to the idea of 5G replacing Wi-Fi. Put simply, on a 5G network, the carrier owns the data, not you. That has all manner of worrisome implications for businesses wanting to protect their data and use analytics, and raises the prospect of carriers selling data back to clients.

Long story short, 5G and Wi-Fi are complementary and synergistic, not antagonistic technologies. When you dig down into the 5G backbone, you find Wi-Fi as a component part. Likewise, as 5G is increasingly used to provide internet connections to homes, Wi-Fi technology, including Wi-Fi calling over cellular networks, will remain key to enabling seamless connectivity and functionality.

5G shares many characteristics with Wi-Fi 6E, but it's a complementary technology rather than a competitor.

above: Intel's 11th gen vPro mobile platform brings 6GHz wireless to professional laptops.
Right: Intel's Wi-Fi 6E AX210 M.2 card will add Wi-Fi 6E to compatible laptops.

years, before Wi-Fi 6E hardware becomes more commonplace.

A further corollary benefit that flows from the lack of channel overlapping and contention in the 6GHz band is lower latency. Not only does waiting for a given channel to become clear before transmitting hobble throughput, but that waiting time also increases latency. Some early movers in the Wi-Fi 6E hardware market are making spectacular claims of sub 1ms latency.

That's yet to be proven. But even if sub 1ms isn't achieved, the simple fact of lower contention and less interference will ensure that Wi-Fi 6E still offers major improvements in latency. Will it be enough for truly lag-free gaming, or good enough for VR applications, which are hyper sensitive to latency? That's the promise, and we'll see soon enough. Certainly Wi-Fi 6E will deliver the best wireless VR experience yet.

All that sounds promising, but are there any downsides? One obvious disadvantage of the new 6GHz band is range. Like other Wi-Fi technologies, Wi-Fi 6E transmits in the microwave segment of the electromagnetic spectrum. Microwaves fall between the shorter wavelength infrared spectrum and longer wavelength radio waves.

More generally, higher frequencies imply shorter wavelengths. All other things being equal, shorter wavelengths allow for greater bandwidth, while longer wavelengths enable greater transmission range. That's because shorter wavelength energy is more easily absorbed by materials and matter of all kinds, from walls right through to air particles. Long story short, then, 2.4GHz has the best range, while 6GHz has the best bandwidth. However, the really clever bit is that Wi-Fi 6E is a superset of Wi-Fi 6. That should make the creation of wireless networks that offer the best of both worlds—range and bandwidth—possible.

For example, a mesh network might use 6GHz to connect the extenders or access points at high speed, while using smart algorithms to connect to client devices at 2.4GHz, 5GHz, and 6GHz, depending on range and any physical obstructions. Scaling back to 2.4Ghz and 5GHz outside is particularly likely given one of the other shortcomings of Wi-Fi 6E—the fact that the 6GHz spectrum has some licensed users.

However, because Wi-Fi 6E augments rather than replaces existing Wi-Fi standards, any given wireless network implementation will be able to pick and choose among a much wider array of frequencies, bands, and channel widths to deliver the best-possible performance to users in any given scenario. Whether it's physical barriers, local interference, or just a huge number of devices nearby, Wi-Fi 6E brings such a huge increase in usable spectrum that it should have the answer to any situation.

Even when Wi-Fi 6E can't directly improve network performance, it will help free up the airspace for legacy Wi-Fi networks to perform more optimally. The result will be speedier wireless networks for decades to come. It really is that big a step change in wireless technology. ⏻

WHAT'S IN A NAME?
HOW DOES WI-FI 6E FIT INTO THE WI-FI HIERARCHY?

Remember the good old days of wireless g, n, and ac? Well, they're gone, replaced by Wi-Fi 4, 5, 6, and now 6E. Of course, much of this is mere rebranding. Under the new nomenclature, what was once rather clumsily known as 802.11g wireless networking is now known simply as Wi-Fi 3. Similarly, 802.11n becomes Wi-Fi 4, 802.11ac is renamed Wi-Fi 5, and 802.11ax is the latest Wi-Fi 6 standard.

But what of Wi-Fi 6E? In simple terms, it's any Wi-Fi 6 device capable of operating in the 6GHz spectrum. In other words, 6E is simply 6 "extended" into the 6GHz spectrum. That definition was made official in January this year when Wi-Fi 6E was certified by the Wi-Fi Alliance, the industry standards body that oversees interoperability and backwards compatibility, and also ensures that Wi-Fi 6E supports the latest WPA 3 security features.

It also means that Wi-Fi 6E adopts the full MU-MIMO capabilities of 802.11ax or Wi-Fi 6. MU-MIMO was already a part of previous Wi-Fi standards. It's a technology that creates support for multiple device transmission on a single Wi-Fi channel, reducing the need for devices to wait for the Wi-Fi channel to which they are connected to become clear before transmitting.

Previous standards supported up to four devices transmitting in parallel. Wi-Fi 6 and by implication Wi-Fi 6E ups that to eight devices. Wi-Fi 6E's status as an extension of Wi-Fi 6 also ensures it will be backwards compatible with existing Wi-Fi access points. However, it won't be possible to upgrade existing Wi-Fi 6 devices to support 6E, be that through firmware or similar avenues.

Wi-Fi 6E is set to be a comms revolution.

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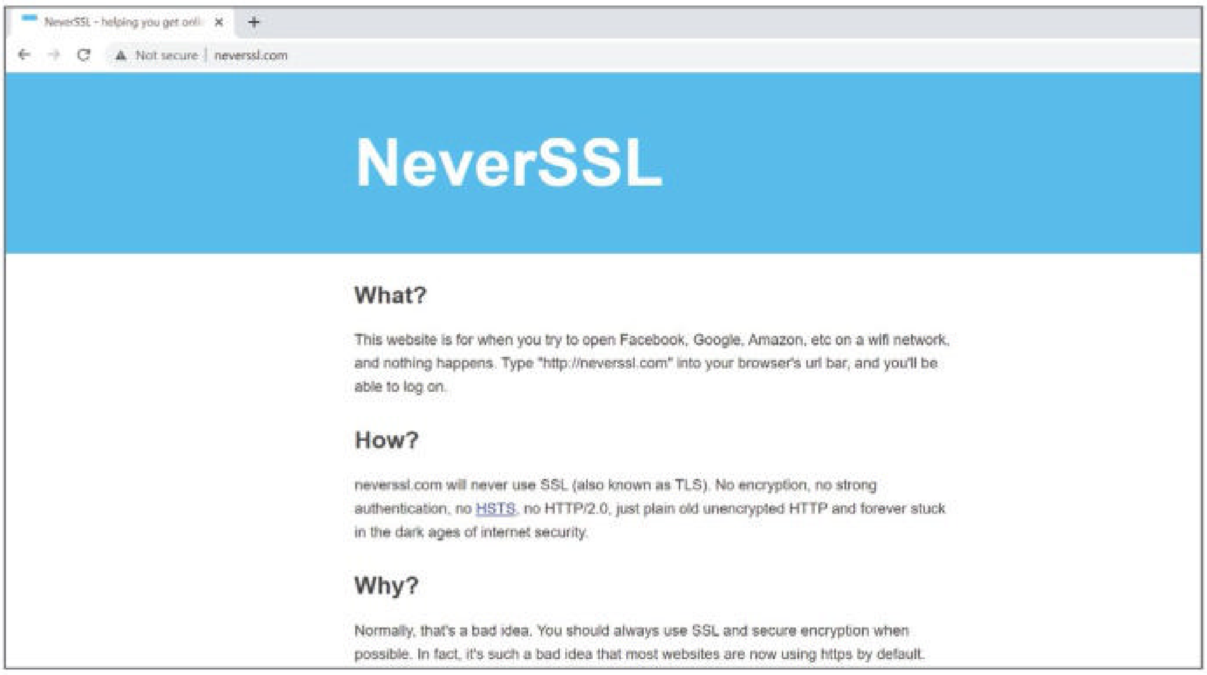
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



NeverSSL

What?

This website is for when you try to open Facebook, Google, Amazon, etc on a wifi network, and nothing happens. Type "http://neverssl.com" into your browser's url bar, and you'll be able to log on.

How?

neverssl.com will never use SSL (also known as TLS). No encryption, no strong authentication, no HSTS, no HTTP/2.0, just plain old unencrypted HTTP and forever stuck in the dark ages of internet security.

Why?

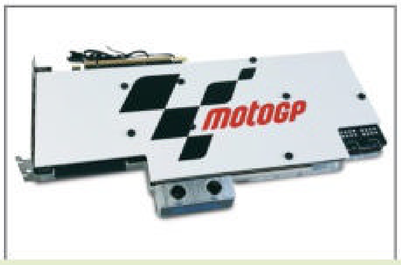
Normally, that's a bad idea. You should always use SSL and secure encryption when possible. In fact, it's such a bad idea that most websites are now using https by default.

TIP OF THE MONTH

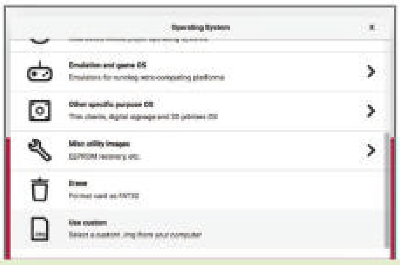
Ever find yourself on the go and needing public Wi-Fi quickly, but you just can't get to the dreaded sign-in page/landing page? Well, fear not, make a connection with the public Wi-Fi, then simply type "neverssl.com" into the search bar of your browser. It will force you onto the landing page to connect to the Wi-Fi, and hey presto, you're good to go. Neat, right?

MAKE – USE – CREATE

60
We're back with part 2 of how to use Photoshop



64
Make your own custom graphics card backplate



66
Turn a Raspberry Pi into a Chromebook

© NEVERSSL.COM, ADOBE, RASPBERRY PI FOUNDATION

SAM LEWIS
STAFF WRITER

BACK IN THE GROOVE

This first month working for *Maximum PC* has certainly flown by. My brain has been flooded with tech, and I can't say I'm not enjoying that. The transition from MacBook back to Windows has been joyful, to say the least, experiencing the freedom of a less limited OS . Gaming is something that I have now been able to pick up once again. Coming from console gaming to PC just makes the last few years of my gaming life seem laughable. Things like load times and simply being able to run games over 30fps are not to be swept under the rug, trust me.

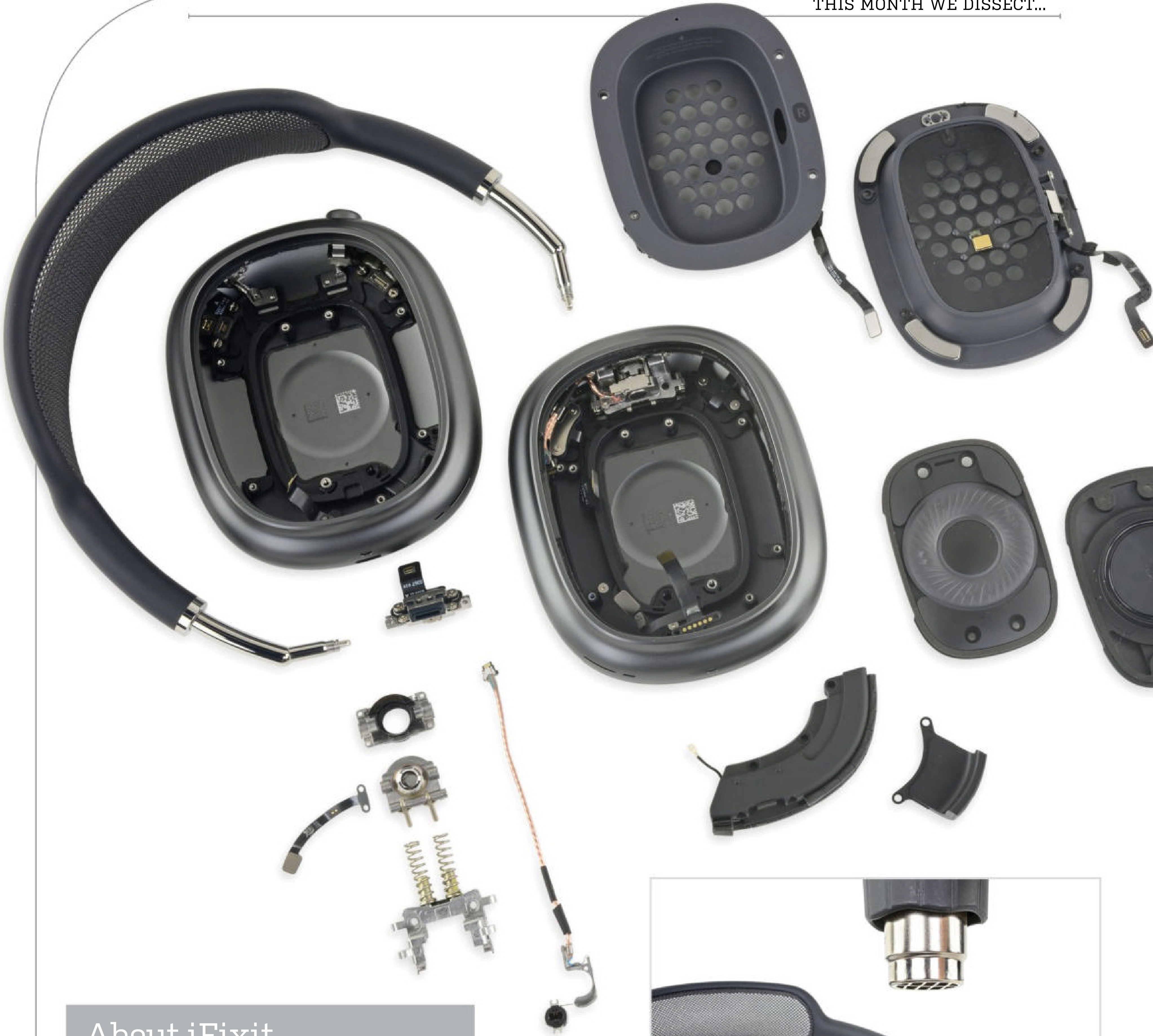
Headphone testing has been one of my first tasks here, and I have to say I was very excited to get my hands dirty in this department. Music has been something that I have taken with me through my life, and getting the chance to test various headphones—I'll snap your arm off to get this opportunity every day of the week (for legal reasons I'm speaking metaphorically...).

Stepping back into this industry and getting familiar with all the ins and outs of tech products is something I've always been interested in. Getting to know every little detail and the really intricate parts of what makes tech work is an area that I love delving into, and I can't wait to experience more of this in the future.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents: AUTOPSY

THIS MONTH WE DISSECT...



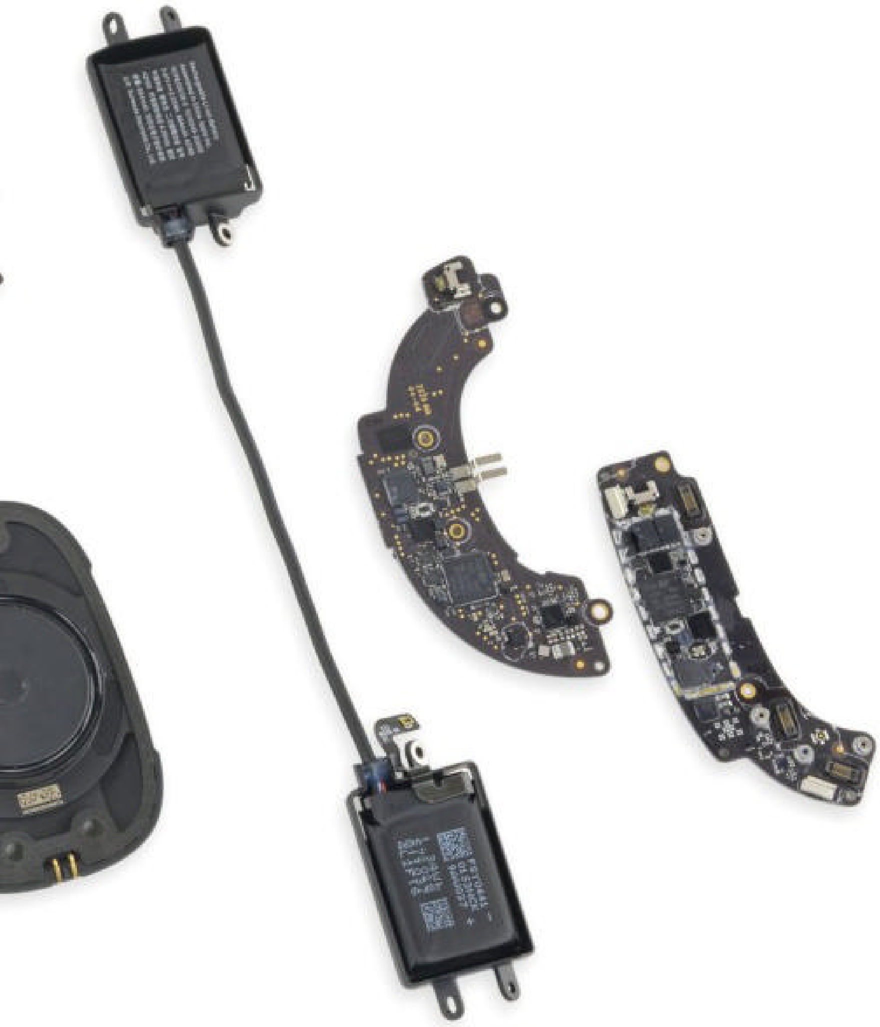
About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Out comes the heat gun, which must be wielded very carefully to avoid melting all this plastic.

The name “AirPods” can now refer to either tiny little in-ear headphones, or these cavernous, over-ear Max headphones

Apple AirPods Max



The heart and soul of the AirPods Max.

BACKGROUND

With a name like AirPods, we had to know: will the AirPods Max be serviceable to any degree? Or did Apple spend a good chunk of the $550 price on over-engineering them into knots?

MAJOR TECH SPECS

- Two 40 mm Apple-designed dynamic drivers
- Two color-matched magnetic ear cushions
- Two Apple H1 chips
- Eight microphones for active noise cancellation
- Bluetooth 5.0 with support for the Apple-friendly AAC codec

KEY FINDINGS

- Along the bottom edge you’ll find a few holes, but none are the round 3.5mm kind. Instead, wired listening is handled by the Lightning port, pulling double duty for listening and charging.
- The first step in disassembly is removing the magnetic ear cushions. Underneath the ear cushions: holes! And are those screws? We’re not fighting glue yet. These are already looking like a promising departure from the rest of the AirPods we’ve previously scalpeled into submission. The less-than-good news is, they’re Pentalobe screws. Luckily we came prepared for just about any kind of screw thanks to our Marlin screwdriver set.
- Those screws got our hopes up, but they behave strangely. They turn a little way in each direction, then stop. If you forcibly remove them like we did, you’ll be rewarded with the sound of loose pieces rattling around inside the earcups—which remain sealed shut. The next round of frustration: adhesive. That’s right, releasing the locks and/or removing the screws isn’t enough. There’s no clearance at all for prying these things out by the edges—you’re going to do some damage. Since we’ve already removed the screws, we use a dental pick to hook under the screw holes and pull. Finally, we’re in! With the screws removed, the drivers flip out, revealing a pair of repair-friendly spring contacts underneath. To our relief, both cells are fastened with screws. Even better, they provide power via a single, iPhone-style pop connector—no solder here.
- Next, the logic board. There’s a unique board in each side—we extract both. Behind the two exterior slits on the lower corner of each can is a plastic air channel, which passes through to the cavity behind the driver. Presumably, this is the ventilation system that gives those drivers their distortion-free oomph at higher volumes. Hiding beneath that antenna line on the left ear cup is a big antenna. We thought this might be a counterweight, to offset the batteries in the opposite earcup—but it weighs next to nothing. The upper microphones are secured with metal brackets, screwed, and plastic-riveted into place.
- Any good headphone headband has to tilt, spin, and connect the earcups. Apple uses a wrap-around flex cable in the rotating portion of the joint, with clever routing and built-in strain relief—then switches to spring contacts for the connection to the headband. Despite the joint’s complexity, you can detach the entire headband with just a SIM card removal tool or paperclip. Fully assembled, a poke in the right place compresses two tiny springs in the joint, freeing a clamp that secures the headband.
- AirPods Max Repairability Score: 6 out of 10 (10 is easiest to repair). The ear cushions attach (and detach) magnetically. The headband detaches from earcups with a poke from a paperclip or SIM card tool. Drivers and battery are secured with screws and use repair-friendly board connections. While screws are preferable to glue, the sheer number of screw types here is baffling. Pentalobe screws and adhesives guard the earcups. ⏻

How to Use Photoshop Part 2

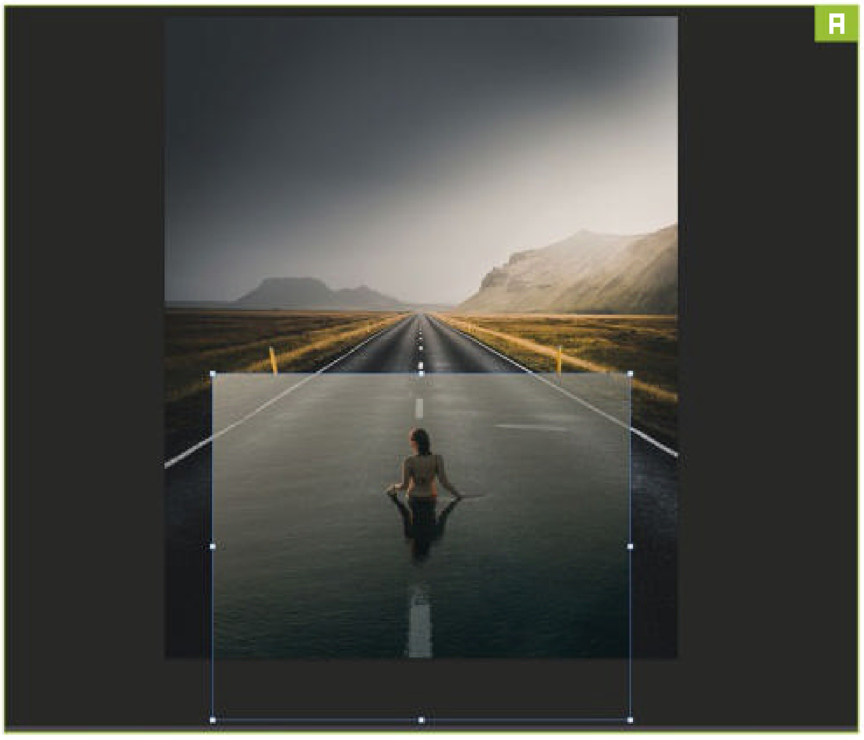
YOU'LL NEED THIS

ADOBE PHOTOSHOP CC 2018 ONWARDS
Windows 10 (64-bit) version 1809 or later.

To view compatibility visit: https://helpx.adobe.com/photoshop/system-requirements.html

IN THIS TUTORIAL, we will be looking at combining images, rather than removing something from a picture. In more technical terms we call it blending an image. It's a nice feature to learn and play around with to get a better understanding of Mask layers and other tools within Photoshop. We will also go into how composition affects an image, and how to get the perspective correct. These are big factors to consider when blending images, as you don't necessarily want to create something that looks too out of place or in your face.

Using the techniques we'll cover here, you will be able to create some very abstract artwork that can be used for a variety of reasons. Image blending is handy for creating striking imagery for publishing design, marketing advertizements, or maybe just for your art. If you haven't done so already, have a look back at our previous issue to get more familiar with Photoshop by working your way through the first tutorial. What we will do in this issue is create some surreal artwork to get a feel for blending. Messing around and having a bit of fun will give you more confidence with the software. If you want to create something silly, be our guest. **–SAM LEWIS**



1 COMBINE YOUR IMAGES

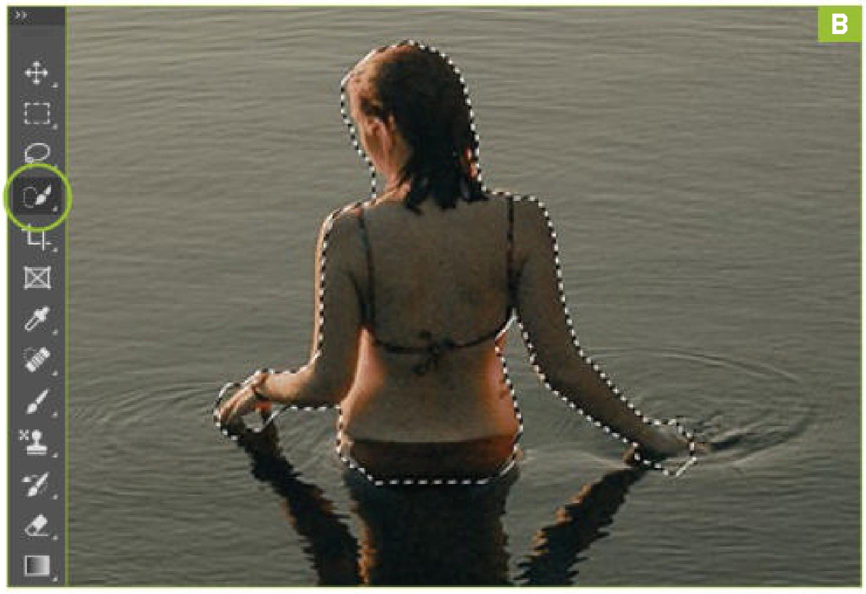
The first things you are going to need are two images that you want to combine. A lot of people use this method to create illusion artwork. Finding images with a similar existing color style will be easier to work with. For no reason other than it looks aesthetically pleasing, for our example we are going to make this swimmer appear like she is wading through the road for an illusion effect. Both images chosen have dark, moody tones, which is handy for color matching.

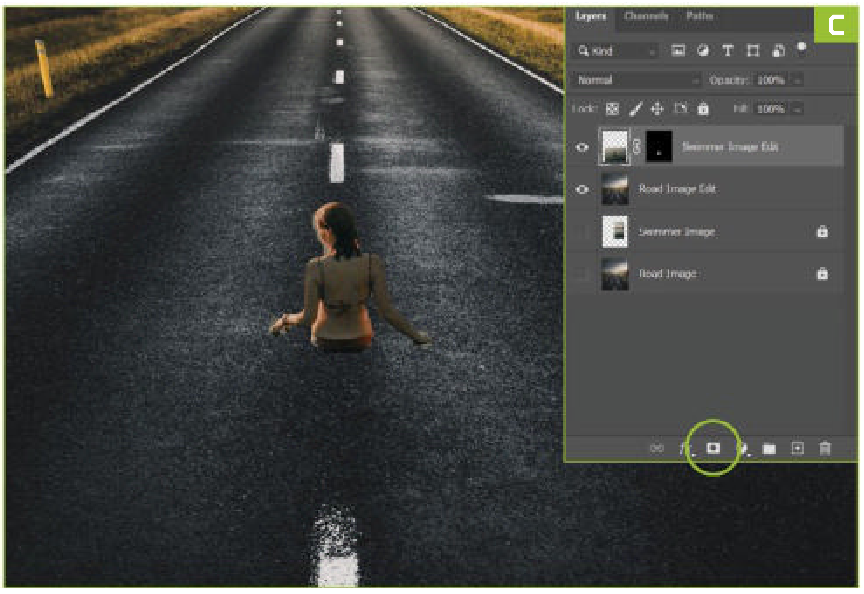
›› So, we have both images at hand, and as you can see, the swimmer image is placed on top for now. When importing your images, if the background image is in front, rearrange the layers by simply dragging them in the Layer panel to the right. Here we have also duplicated the original images, locked them, and hidden them, just like we showed you how to do in the first tutorial. This is in case we make mistakes that are beyond the undo tool and need to start from scratch. Don't worry if that happens, we have all been at that blood-boiling stage.

›› To start things off, make sure the composition of the image is correct. Composition is everything in an image—it needs to look correct, and fit in with the perspective of the shot. Take your time getting your foreground image in the right place to create something that looks natural. In this case, we've dropped the Opacity of the image to make it easier to see what the finished outcome might look like. By pressing Ctrl + T when on the correct layer, you can quickly scale the picture up and down. We've scaled the swimmer to a realistic size and centralized her, as she is the main focus of the image [**Image A**].

2 QUICK SELECT

Once you have all your imagery in place, you can get cracking with the magic. For our example, we will put the Opacity back to 100 percent, and then make a selection of the swimmer. To do this stage, we are going to use the Quick Selection tool to select the swimmer. Find the tool under the Tool panel to the left of the screen, or hit the W key for a shortcut to the tool. Zoom in and draw over the swimmer to make a selection [**Image B**]. Don't worry about being super-accurate, as this is something you can sort out later on. If you do want to be more accurate and the Quick Selection tool isn't quite cutting it for your image, then you can use the Pen tool (P) to draw around the selection instead.




C
Layers
Channels
Paths
Swimmer Image Edit
Road Image Edit
Swimmer Image
Road Image

›› Once the selection has been made, make a mask of this image. The Mask icon is located at the bottom of the right panel on standard formats of Photoshop. It is a white square icon with a black circle in the center—click this to make a mask, and make sure you are on the correct layer. If you can't find this go to "Layer → Layer mask → Reveal selection." All aboard? Hopefully, it should look something like this [**Image C**].

3

PAINT IT BLACK AND WHITE

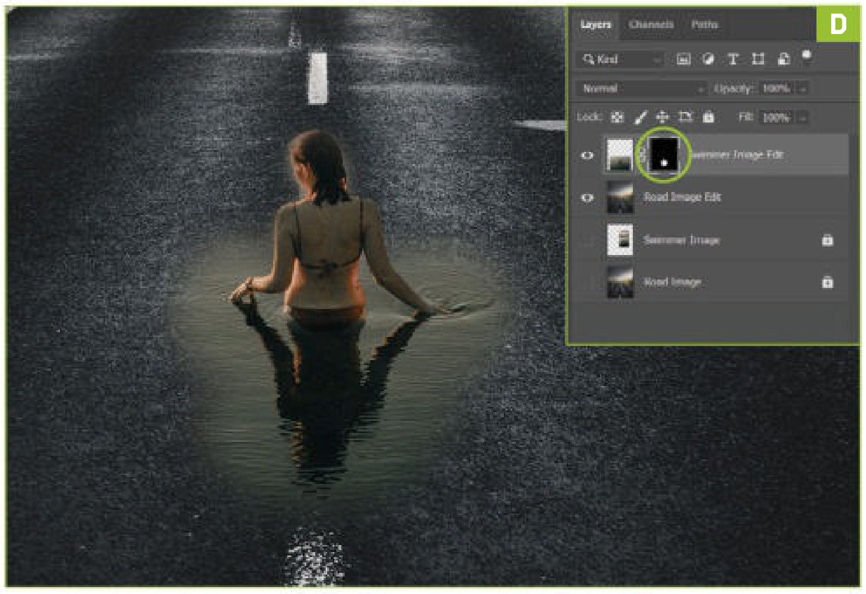
As you can see, the image is getting there but needs a lot of cleaning up, as well as blending. Using the Brush tool we will bring some of the water from the swimmer's image into the background image to blend with the road. Make sure you click on the masked layer on the swimmer (the black square icon within the layer) and then hit B to quickly bring up the Brush tool. Before you go any further, right-click when you have the Brush tool selected and make sure Hardness is at 0 percent. When using the Brush tool in the Mask layer, when you paint white it brings back the image, and when you paint black it erases the image. This is a very easy way to add the background into the swimmer's cropped image.

›› We are now going to do that by painting white around the swimmer to bring back some ripples and her reflection, as seen below [**Image D**]. If you want to quickly change between white and black, hit the X key—a nifty shortcut to switch between selected swatches. Luckily, black and white are the selected swatches by default. Once painted around, the image should look similar to ours.

4

DARKEN COLOR LAYER

The image is starting to fall into place, but as you can tell, it still needs blending. So the next step is to create


D
Layers
Channels
Paths
Swimmer Image Edit
Road Image Edit
Swimmer Image
Road Image

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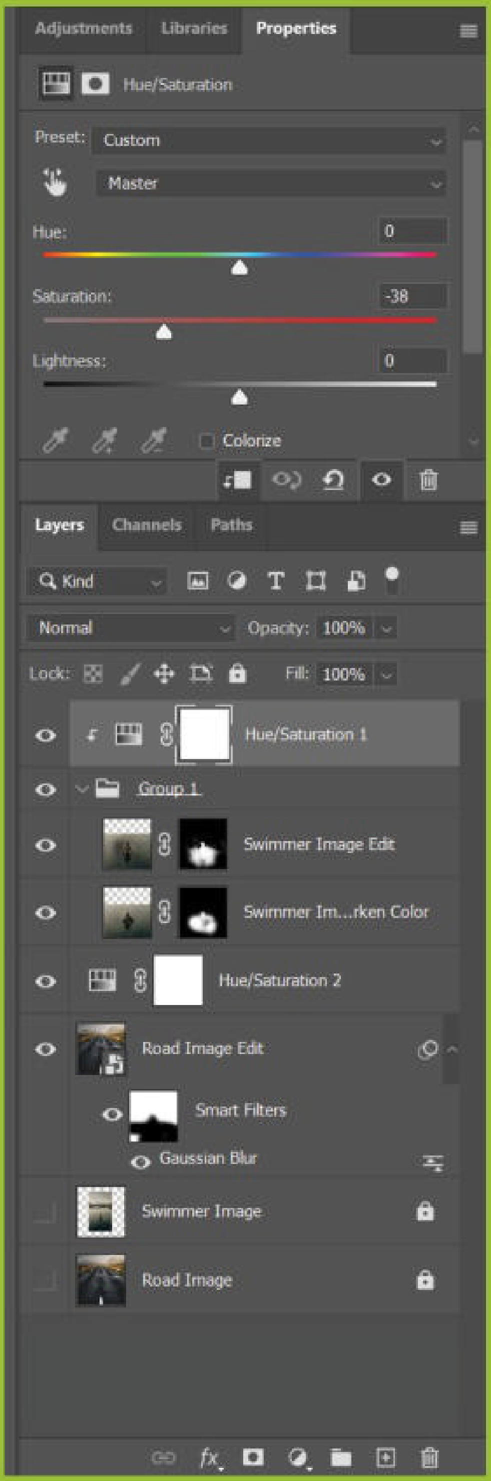
RIGHT-PANEL TOOLS


Adjustments
Libraries
Properties
Hue/Saturation
Colorize
Layers
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Kind
Lock:
Hue/Saturation 1
Group 1
Swimmer Image Edit
Swimmer Im...rken Color
Hue/Saturation 2
Road Image Edit
Smart Filters
Gaussian Blur
Swimmer Image
Road Image

Preset: Custom
Master
Hue: 0
Saturation: -38
Lightness: 0
Normal
Opacity: 100%
Fill: 100%

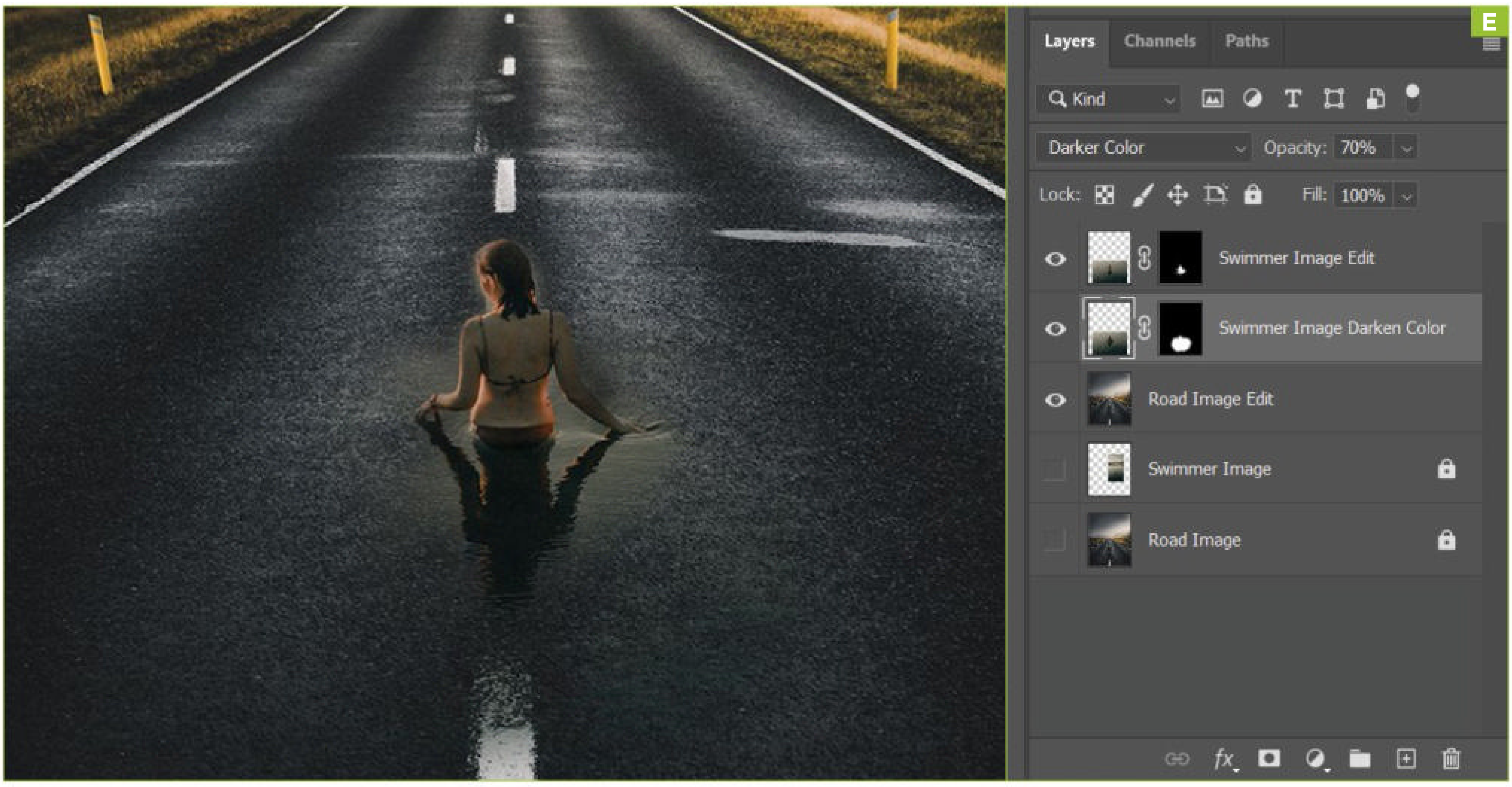
For this tutorial, we are working mainly with the right-hand panel of tools. At the bottom, you can see buttons for FX, used for glows, overlays, and blending options, then the Mask layer icon is next to that. This is heavily used in this tutorial to add and subtract elements of an image. To understand the Mask layer easier, replace the word "mask" with "transparency." There is already a Transparency/Opacity slider, but what that does is apply the opacity to the whole layer. A Mask layer enables you to choose exactly what part you want to be seen or not.

Next along is the Adjustment layer. It adds a layer to the top, which gives you multiple options. These include: Hue/Saturation (used in this tutorial); Invert color, Levels, Black and white, Brightness/Contrast. The options for what Adjustment layer you select will appear under the Properties tab above the layers, seen in the image we have here. It is a nice and quick way to apply effects to a layer and fine-tune them.

The folder icon is the group button. Instead of using Ctrl + G, select the multiple layers you want while holding Shift, and click this to group them. The last two icons are easy enough to remember; the plus icon is to add a new layer, and the bin icon is to delete the selected layer you are on. Simple enough, right?

The last thing to mention is that if any layer has another box thumbnail next to the image, then it is likely that a mask is in use. When there are black boxes you can see where the image has been drawn on by the white markings, just like a preview.

These are the main areas focused on in this issue's tutorial, which will hopefully find themselves being used in your own projects.



a Darken Color layer. Duplicate the Swimmer layer, and rename the bottom of the two layers something like "swimmer image darken color." Naming layers is crucial in Photoshop [**Image E**]—it helps to keep you organized so you don't get into a huge mess, which is easily done—try not to learn it the hard way.

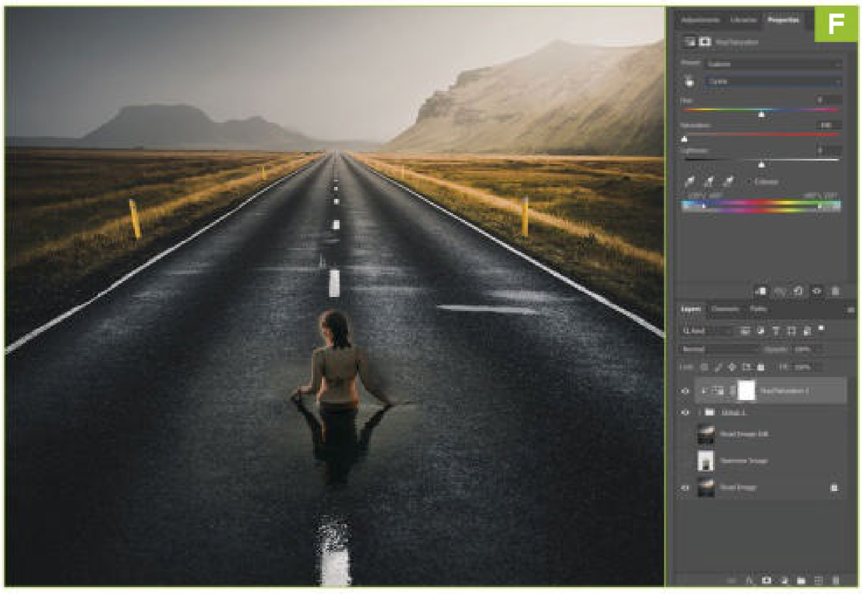
›› When the layer has been duplicated, select the Darken Color layer, and go into the Blend options. This tab should say "Normal" and is found above the layers. When you click on this it gives you all the blending options—the one you want is "Darken color." Next, make sure you click on the mask section of the Darken Color layer, get the Brush tool, then paint more of the water around the swimmer. This adds a darker edge around the subject. To blend it with the road more, drop the Opacity of the Darken Color layer to something around 70 percent.

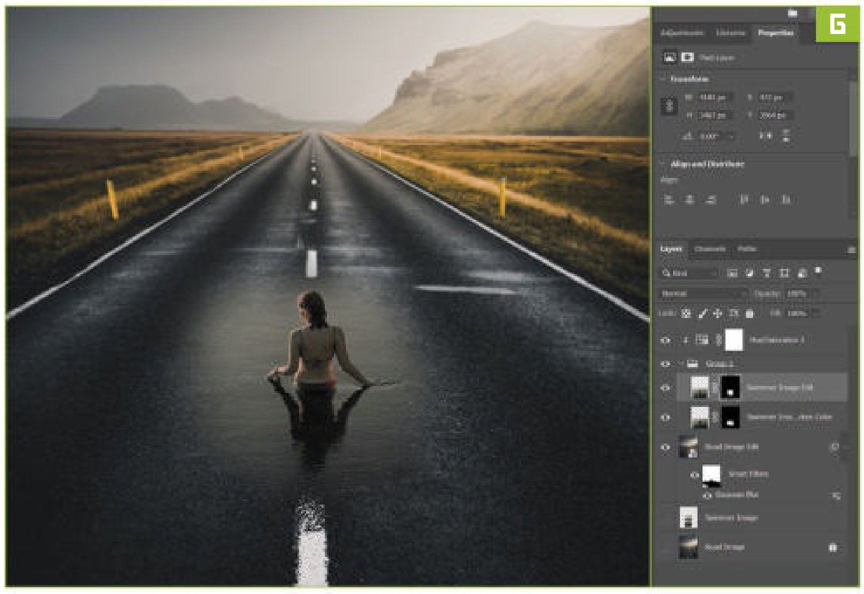
5 ADJUSTMENT LAYERS

After the Darken Color layer is done, we will group it to the Swimming layer above it. A shortcut for this is to highlight them both by clicking and holding Shift, then press Ctrl + G, and rename that to "Swimmer" to keep things tidy. To blend the water with the road we will be creating an Adjustment layer [**Image F**]. With the group selected, click on the Adjustment layer icon, which is to the right of the Mask layer icon that we used earlier. It will give you a list of options—you are going to want to open up the Hue/Saturation option. As this pops up you will then need to make sure that the Clipping mask is on for that layer.

›› This means that whatever adjustments you make only apply to the bottom layer (Darken Color layer of the swimmer). In this panel, click where it says "Masters," and select the colors that you want to blend—in our case, cyans, blues, and greens to cover all colors—then turn all of the Saturation down to 0 for those colors. Keep adjusting until you feel it looks correct.

›› You can always go back into the group layers and play around with the Mask layers. If you need to add more to the masks remember to paint in white, and paint in black to remove. If there are any further adjustments that you feel will benefit the image then apply them—for example, reduce some Opacity on the group layer a bit, which can help with blending. In this example, the Opacity of the group layer has been reduced to 95 percent to let more of the road color come through the water. [**Image F**]





6 SMART OBJECT

For the next stage, we are going to be focusing on the background layer by giving it some depth. First, make it a Smart Object. Making something a Smart Object is super-simple: right-click on the Background layer, then click "Convert to smart object." To apply the blur effect, head over to filter at the top, then "Blur → Gaussian blur." A pop-up will appear and change the pixels to around five or six, whatever suits your image most. As you may notice, the whole image is blurred, but you only need the background—this is where the Smart Object layer comes into play. Click on the Smart Object box in the Road layer. Use the Brush tool, and paint away from the foreground of the image using black, just like Mask layers. This brings focus to the swimmer and blends the background. Sometimes this can alter the image, and in our case it has, so we've gone back to the original mask and added more water to the image. [**Image G**]

7 FINAL TOUCHES

In our example the water's still too bright. To darken the water we've gone into the Swimmer layer and selected the Burn tool (O). There are two other tools under this shortcut—Sponge, and Dodge. The Burn tool adds a small amount of darkness where you paint it, so we've gone around the water to apply this [**Image H**]. Also, to help with composition, we'll crop to ensure that the swimmer is the main focus, cropping some of the sides and top off of the background. Next, we'll slightly scale up the swimmer, and decrease the background saturation to help with blending.

›› Hopefully, this tutorial has added some more tips and tricks that you can use to help an image blend more into a background, merging colors and using Mask layers. Play around with other images you have to try and combine the two. See how far you can go with it, and let your imagination run free. The more you enjoy Photoshop, the easier it will be to create some seriously interesting pieces on it. You may discover a niche interest in photo manipulation you didn't know existed, or even take it to a commercial level—who knows. ⏻

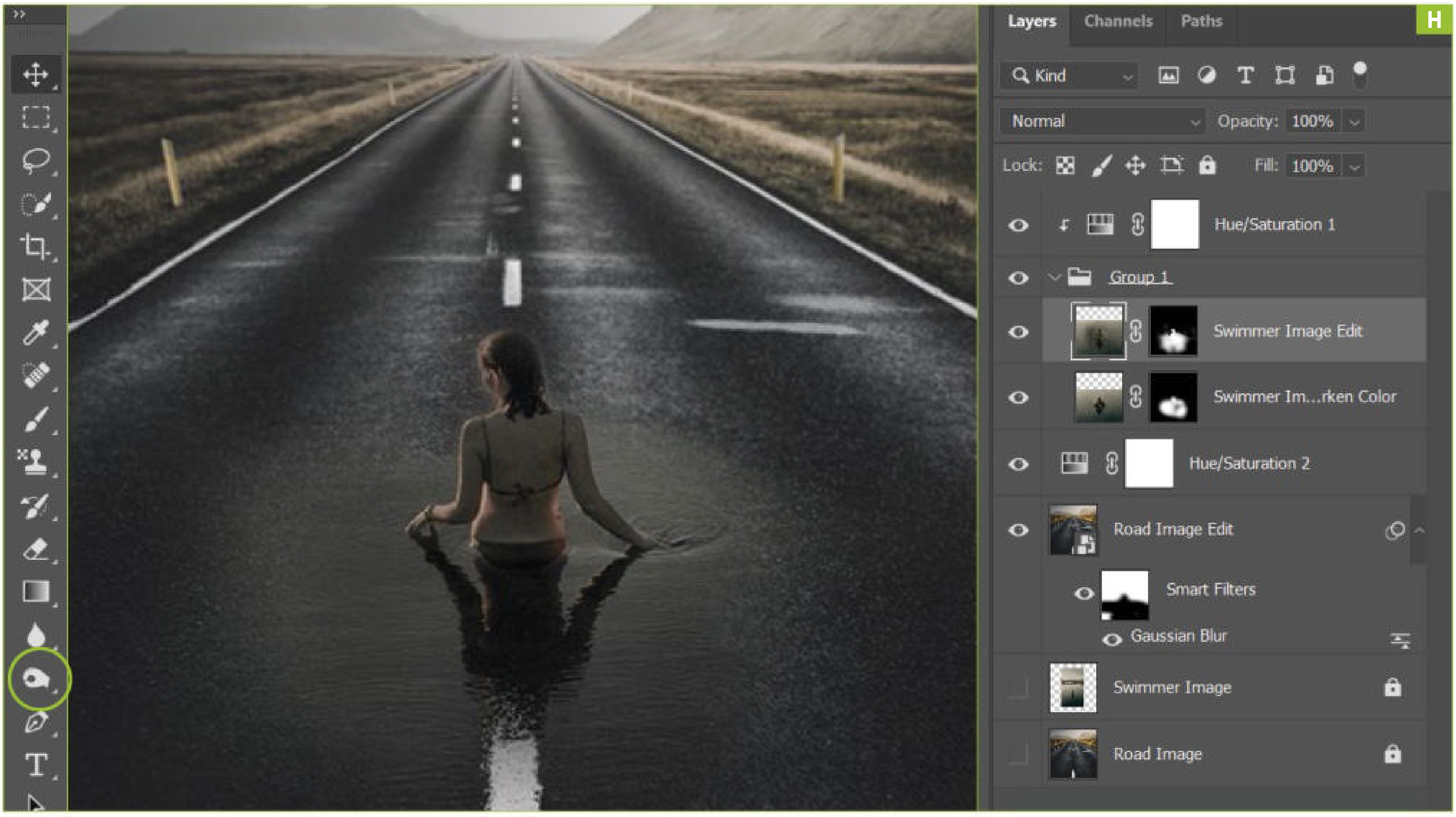
COMPOSITION IN PHOTOSHOP

Every single Photoshop project should take composition into consideration. In fact, it is one of the main priorities of your frame when taking a photo or producing some artwork. In Photoshop, it is talked about in relation to how the subject of the image sits in the frame, and how it blends with the background. In short, it is how the image is arranged and organized, and there are a few factors that are required in order to make this work. It is how you choose to arrange the elements that can make or break a shot, design, or edit.

Some factors that heavily influence the composition of an image are perspectives and angles. If you are bringing an image into another image, then it is something that is going to require more thought. Make sure that both images follow a similar angle to begin with, as this will help reduce the amount of skewing and distortion needed. If you are creating something that you want to look authentic, make sure that the heights of certain objects are relative to the background. A human is never going to be taller than a house—well probably not, anyway.

Another element to consider is the shape and form factors. An image in Photoshop is a 3D representation of a scene. The more depth that this image has the more interesting it is to look at. This can be achieved by perfecting your arrangement and creating an intriguing composition.

The same can be said for color and shading. You can use this to your advantage to make things appear more 3D than they did originally. To make this work and look natural, the colors need to blend and not stick out like a sore thumb. These factors require patience but are worth their weight in gold when the composition all comes together.



Normal

Opacity: 100%

Fill: 100%

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Make Your Own Custom Backplate

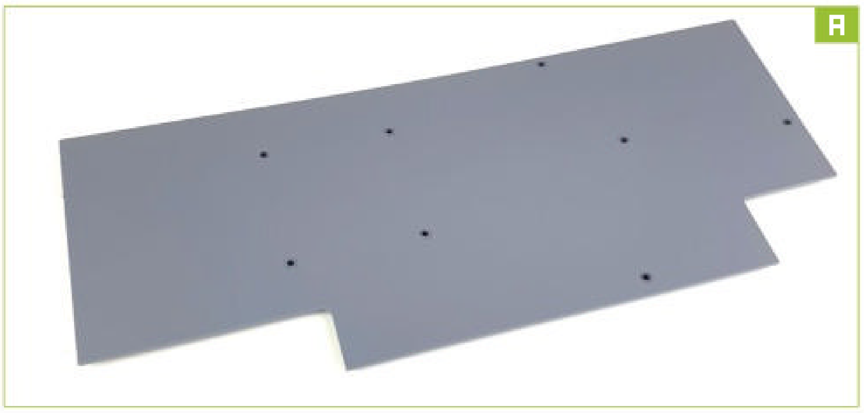
YOU'LL NEED THIS

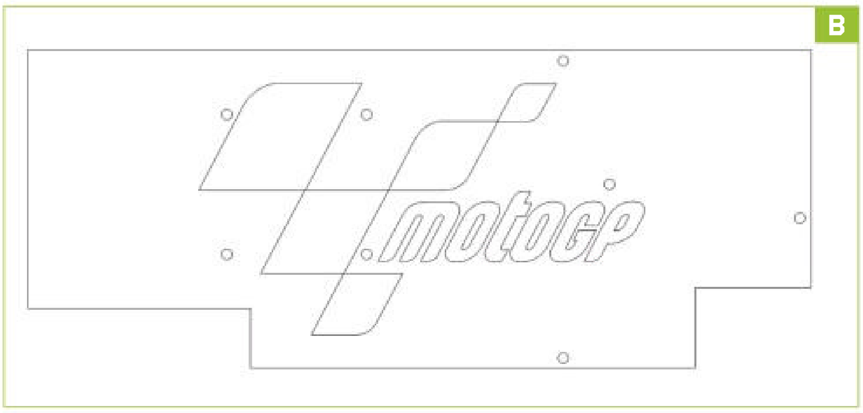
BACKPLATE OR SHEET MATERIAL
Decal or stencil material/vinyl cutter.
Sandpaper.
Spray paints.

WHEN YOU DECIDE it's time to build a new system there is always the vision of how you want it to look. You painstakingly plan out the hardware you are going to use to suit your needs, but aesthetically there are a number of contributing factors that are very personal. You can toy around with cooling options, storage, lighting, airflow, and a whole range of combinations to make it something that has not been seen before. That said, we have seen 1,000 different builds that all look the same, and this can be down to a variety of factors; budget, competence, following a trend, case preference, and much, much more.

Depending on the style of the build you are piecing together, your graphics card not only plays an important role in the function of your shiny new system, but can be a focal point of the build too. It's an integral part of the wow factor in many systems, and it's just another piece that throws many options at you—leave it stock, water-cool it, mount it horizontally, mount it vertically, etc.

If you've blown your budget on performance, there are ways to up that wow factor and give it a personal touch at a relatively low cost. Yes, we are talking about adding a small touch of personal preference by customizing the backplate. Let's get started, shall we? **–KRIS BUTTERILL**





1 SAND AND COAT

There are many ways to create a custom backplate—hand tools, 3D printing, CNC, airbrushing, hydro dipping, and many more. If your card doesn't ship with a backplate, you can build one from scratch using acrylic. Or if it does, you can modify the existing backplate, use the original backplate as a template for a change in materials, or finally—as we are doing—use the backplate that came with your aftermarket water block.

›› The first thing you need to do is sand down the logo and prime the backplate from the shiny new water block, ready for painting. This is the most crucial step in any painting job,to ensure that the final product is the best it can be [**Image A**]. The time spent here will save you a lot of work down the line. So prepare the surface, and once done, make sure it is clean and free from any debris.

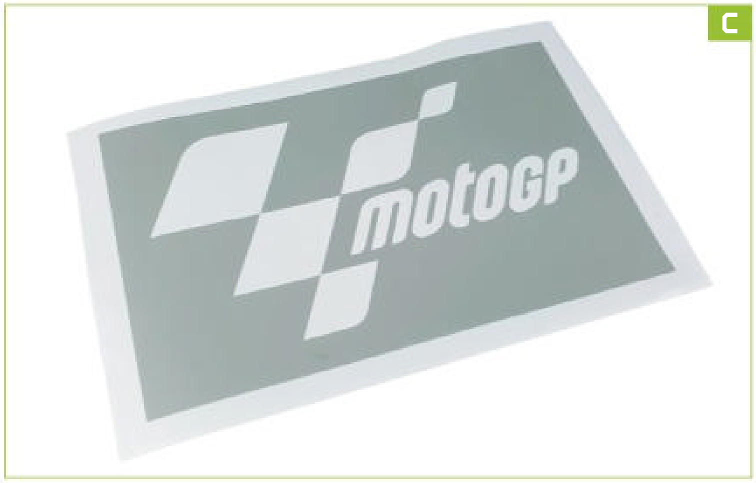
›› For primer, we generally go for two coats, following the manufacturer's instructions on time between coats, and drying time. Make sure the area you are spraying in is free from dust and has good airflow, or wear respiratory protection. If you notice any blemishes or defects in the primer stage, fill, sand, and apply primer coats again, to make sure that the surface is free from imperfections for the base coat of paint.

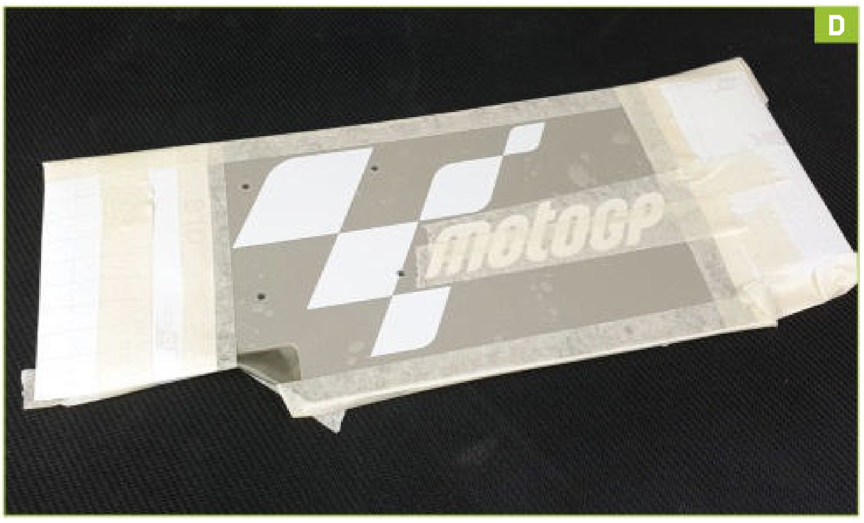
2 BASE COLOR

Now that the backplate is primed and ready, apply the base color. To fit the theme of our build, the backplate will be white, with our stencil then layered on the top. Two to three coats of base paint should give it a nice, even look, and start to transform this regular backplate into a custom design. Try to apply coats from different directions; this will help you get into all the corners, ensuring a good, even coverage. Again, pay attention to the manufacturer's recommendations on spraying distance and drying time. There is nothing worse than applying another coat too early, seeing it run, and having to take back all the work that has been put in so far—slowly, slowly, my friends!

3 MAKE A STENCIL

While waiting for the base color to fully dry, move onto creating the stencil. You can purchase these from many places on the internet, or use a standard decal, or—as we are doing—create one for cutting using a vinyl cutter. We usually use Oramask 810 Stencil





D

Film— it is specifically designed for this type of application, and since it is low tack, it won't lift or peel any surfaces underneath that have already been painted.

›› First, plan the layout. For this, draw up the backplate, using measurements, to try and avoid covering any of the mounting holes for a clean design [**Image B**]. You can then export this to the vinyl cutting software, and create the stencil [**Image C**]. Another option would be to print out the design and use it to trace the outline, using a craft knife to cut the stencil material. If you are ordering online, make sure you check the dimensions before placing the order.

›› Once the stencil has been cut, you can then "weed" the design. This is the process of removing parts where you want the paint to come into contact with the backplate. Remember, this will be the opposite of the logo itself, so take your time to be sure you're removing the right parts!

4

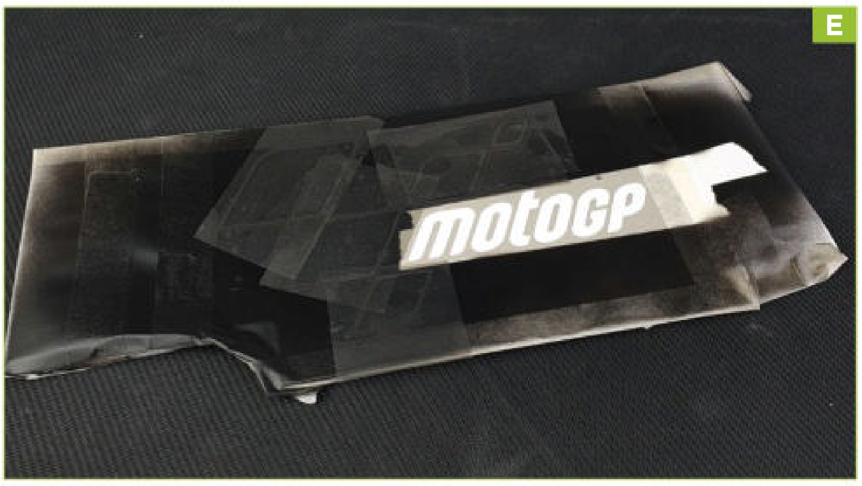
PREP FOR APPLICATION

Now you have your stencil, and the backplate should be ready for the design to be applied. Carefully apply the stencil onto the backplate, ensuring that it is positioned as intended. To transfer the design you can use masking tape or even specialist transfer film. Check that the edges are stuck down firmly to prevent the paint from bleeding under the stencil when it is sprayed—you want a crisp, clean edge to your logo [**Image D**]. In this step, we have also used masking tape and sheets of paper to mask off the areas of the backplate that we don't want to cover with overspray.

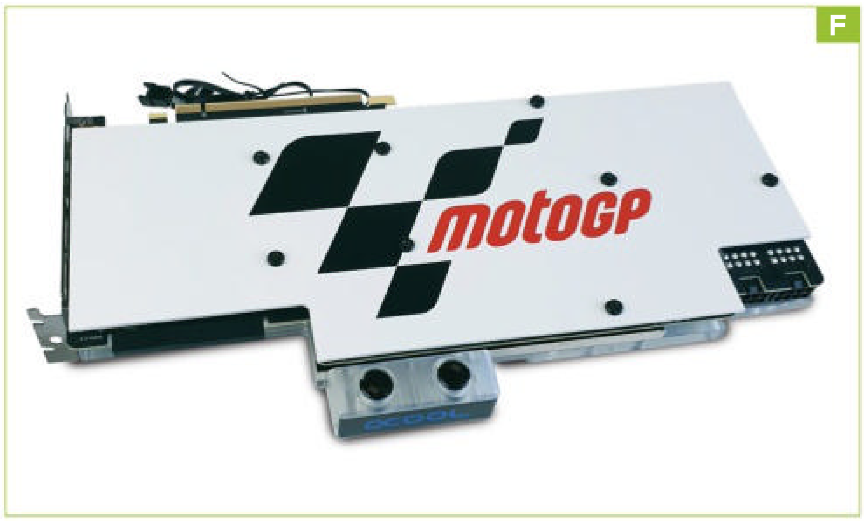
5

APPLY YOUR DESIGN

It is now time to spray your design. Apply thin, even coats until you are satisfied with the overall finish. It may not have to be many coats if you are applying onto a lighter color. Allow each coat and each portion of the logo to dry before moving on to additional colors. If the design is multicolor, mask off each section while you paint one, then rinse and repeat for any other sections. For our example, the Moto GP logo is black for the flag and red for the text [**Image E**].



E



F

›› Once the design is painted, allow it to dry fully, and then carefully remove the stencil mask—peeling at an angle will help prevent the lifting of paint layers. Here you can also opt for a clear coat to protect the design and give it a shiny finish. Personally, we like to outsource this part, as professional sprayers can provide a much better finish than we can produce. Not everyone opts for this step, but bear it in mind if you are looking for a glossy shine for your parts.

6

PUT IT TOGETHER

Now it's time to put it all together and fit the backplate! If you've decided to create one from scratch using an acrylic sheet or similar, you can fix the backplate to the graphics card using double-sided tape, or if you've copied the mounting layout, use the original/replacement screws if possible. For our backplate [**Image F**], we'll mount the water block to the card.

›› If opting for this route, take your time, and make sure that all the thermal pads are correctly installed. Most block manufacturers offer a great set of instructions to follow, guiding you through the process of fitting the block to the card. Be careful when tightening the backplate—sometimes, in thicker parts of the paint, the torque against the screws will be enough to crack your lovely new paint job.⏻

BUILDING CONFIDENCE

With a little time, patience and creativity, making a custom backplate is quite an easy process and helps transform the look of any build. It's also one of the cheapest ways to get into modding—part of the reason we chose to use an existing backplate for this process. There are backplates out there to buy, but why not do something that gets you more involved, and makes the build more personal?

It's a great way for you to build confidence if you are new to modding. Starting small is a good thing, as it allows you to learn the trade, and the steps, to have a better understanding of the processes for future projects.

Perhaps one of the best aspects of this project is that if you do make a mistake, the paint can be stripped back to do again, and it doesn't cause irreparable damage to any hardware. Plus, if you ever change the theme, you can simply repaint the backplate as many times as you want—at least until you grab your next graphics card!

Turn a Raspberry Pi into a Chromebook

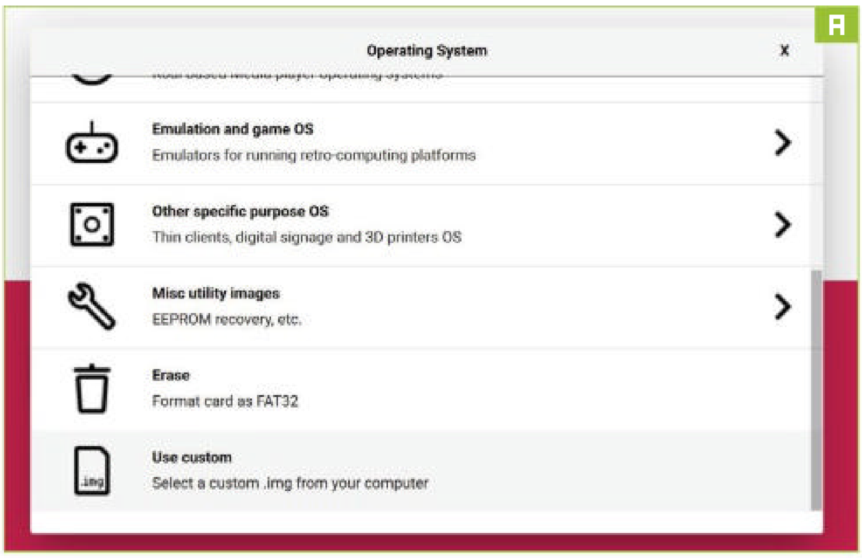
YOU'LL NEED THIS

RASPBERRY PI 3, 4, OR 400
A MicroSD card 4GB or greater.

THE BEAUTY of single-board computers is that they can be switched between operating systems easily—it's just a case of swapping a microSD card over and switching it back on. The operating systems are easy to install too, flashed to a card from your PC with a user-friendly piece of software.

Recently, we showed you how you can use a full 64-bit operating system—Ubuntu—on a Raspberry Pi, and get real work done on a diminutive PC. This time, we're going to do the same thing, but to the opposite extreme. Chromium OS—an open-source version of the Chromebook OS—is as minimal as things come without being a command line, as it's just the Chrome browser. But that doesn't mean it's particularly limited. There's a full office suite in there, cloud storage, image editors, e-book readers, and all sorts of other apps that are available as web apps. With no flashy interfaces or 3D games to distract you, working like this is a low-powered way to get everyday computing tasks done.

It's also quite responsive, which isn't something you can say for some of the heavier operating systems available for the Pi. We're using a Raspberry Pi 4 with 8GB of RAM here, but it will also run on a Pi 400, 3B or 3B+ model. –**IAN EVENDEN**


A

Operating System ×

Emulation and game OS
Emulators for running retro-computing platforms

Other specific purpose OS
Thin clients, digital signage and 3D printers OS

Misc utility images
EEPROM recovery, etc.

Erase
Format card as FAT32

Use custom
Select a custom .img from your computer

1 FLASH

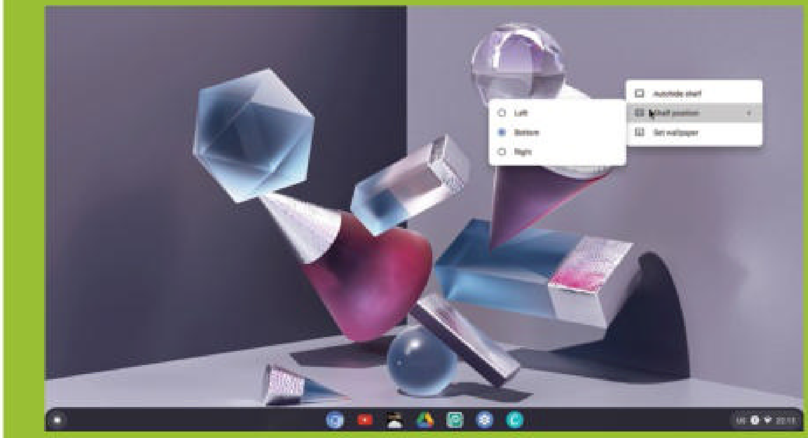
You'll need the Raspberry Pi Imager app to flash the ChromeOS build to a blank microSD card (Chromebooks typically come with 16 or 32GB of local storage, but this version only gives you 4GB, no matter how large a card you use—there's a way around this, though). The app runs on Windows, Ubuntu, Raspberry Pi OS, or macOS, and can be found at www.raspberrypi.org/software. Once that's installed, head to http://bit.ly/MPCaprfydeOS and download the Chromium OS image for your particular Pi model.

» If you want to build the OS image yourself, head to the project's main Github page, and you'll find all sorts of discussion about that sort of thing, along with some known issues, one of which is important and we'll come to later. In the Imager, choose a custom OS, [**Image A**] then point it toward the IMG file you downloaded from Github. Choose the card you want to use, and set it working. We're using R86r2, released on December 30, 2020, but there may be newer releases by the time you read this.

2 BOOT

Put the newly flashed card into your Pi's slot, and switch it on. The first boot can take a little while, but you'll soon be taken through the basic setup routines for the OS, including connecting to Wi-Fi. Chromium OS requires a Google account to sign in with, and if you're a Chrome browser user you get all your bookmarks and extensions synced across. We often find that there's a period of non-responsiveness on the password screen, but it usually clears after 30 seconds so you can log in. It's a minimalist

WALLPAPER AND CUSTOMIZATION



Changing desktop wallpapers in Chromium OS gets its own app, accessible from "Settings → Personalization." It's filled with desktop backgrounds, and a few have the option to refresh daily. There are some beautiful options available, but sadly they don't appear in the Files app. Right-clicking on the desktop gets you a menu, with only three options: to show or hide the dock (actually called the "shelf"); to position the shelf on the side of the screen; and change the wallpaper, which brings up the Wallpaper app. Image files saved to the Downloads folder can be set as a wallpaper by right-clicking them and choosing the appropriate option. Beyond this, there isn't much personalization , apart from changing the picture that appears by your account name.

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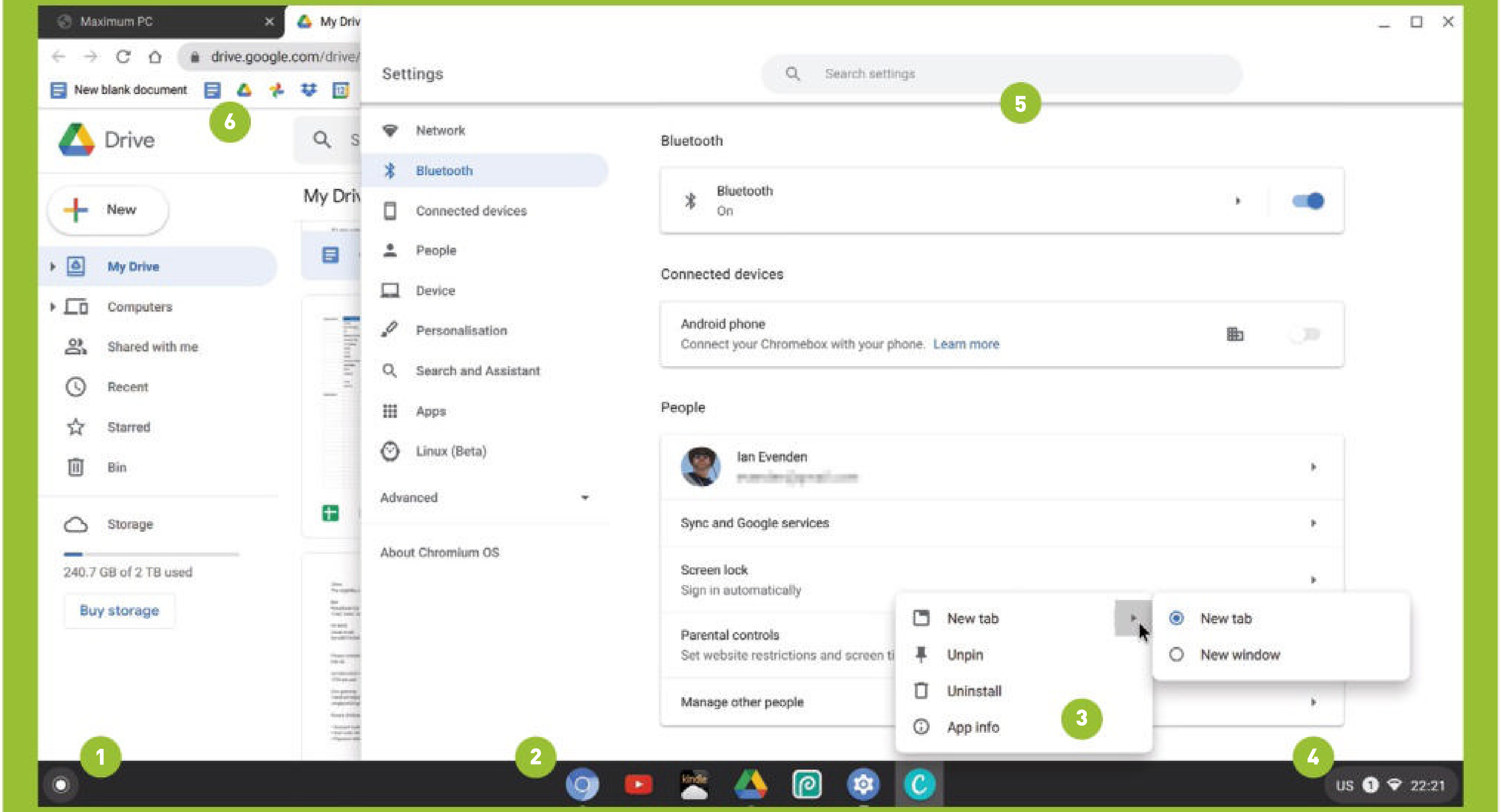
MEET CHROMIUM OS


Maximum PC
My Drive
drive.google.com/drive/
New blank document
Drive
New
My Drive
Computers
Shared with me
Recent
Starred
Bin
Storage
240.7 GB of 2 TB used
Buy storage
Settings
Search settings
Network
Bluetooth
Connected devices
People
Device
Personalisation
Search and Assistant
Apps
Linux (Beta)
Advanced
About Chromium OS
Bluetooth
Bluetooth
On
Connected devices
Android phone
Connect your Chromebox with your phone. Learn more
People
Ian Evenden
Sync and Google services
Screen lock
Sign in automatically
Parental controls
Set website restrictions and screen ti
Manage other people
New tab
Unpin
Uninstall
App info
New tab
New window
US
22:21
1
2
3
4
5
6

1. LAUNCHER
Pop this up to search, or choose from recent apps.

2. SHELF
Not a dock. You can choose which apps appear here in Settings.

3. RIGHT-CLICK MENU
Get some basic app controls with this pop-up.

4. QUICK SETTINGS
Wi-Fi, Bluetooth, volume, power—they're all under here.

5. SETTINGS APP
Make changes to your Chromebox here, but don't expect great depth.

6. THE BROWSER
The full Chrome browser, with extension support. You'll spend a lot of time here.

UI, with a Mac-like dock at the bottom and the browser taking up the rest of the screen—but what more do you need?

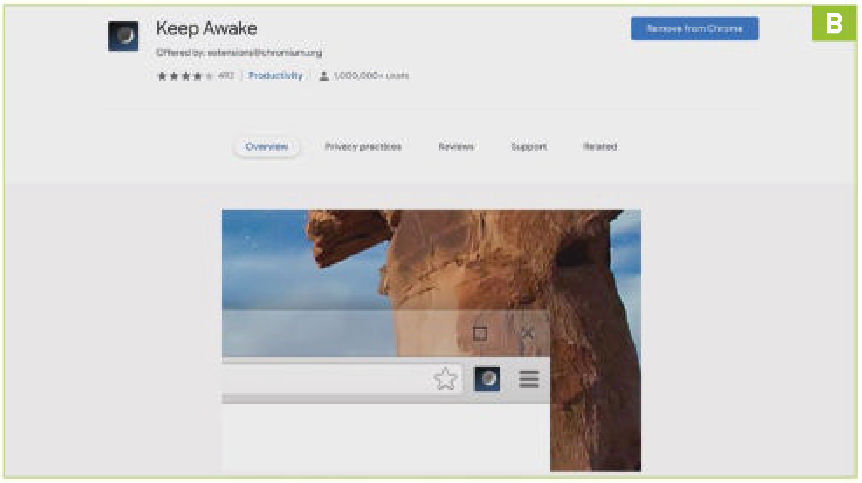
3 EXTENSIONS AND APPS

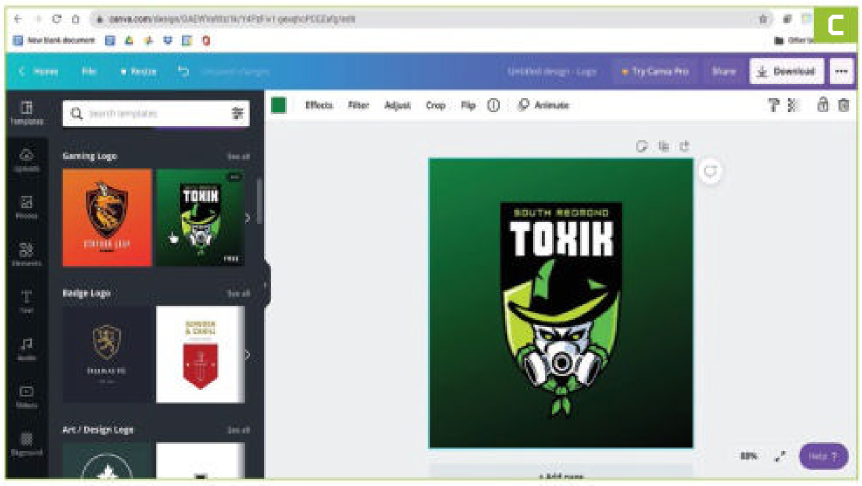
Remember that important issue we told you about? The first thing you should do is open the Chrome Web Store and install the Keep Awake extension [**Image B**]. When that's done, set it to Sunny Mode, which stops your Pi from going to sleep. The developers of this Chromium fork haven't quite worked out the Pi's sleep system, and if it goes to sleep it won't wake up again. Or if it does, the keyboard input doesn't work, and you can't type your password.

» Browse the Web Store and see if there's anything else you need to install—the Chrome Web Store is packed with extensions, though not all of them are compatible. The image editor Polarr wasn't when we checked, but Photopea, which is reminiscent of Photoshop, runs fine, albeit with a large gray bar down the right-hand side. Graphic design app Canva works too [**Image C**] .

4 GOOGLE DOCS

Working with Google Drive and Docs is exactly the same as in any other Chrome browser. Just open them in a new tab, and you'll get the familiar experience.


B
Keep Awake
Offered by: extensions@chromium.org
Productivity
Remove from Chrome
Overview
Privacy practices
Reviews
Support
Related


C
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› DISCOVER GREAT FEATURES
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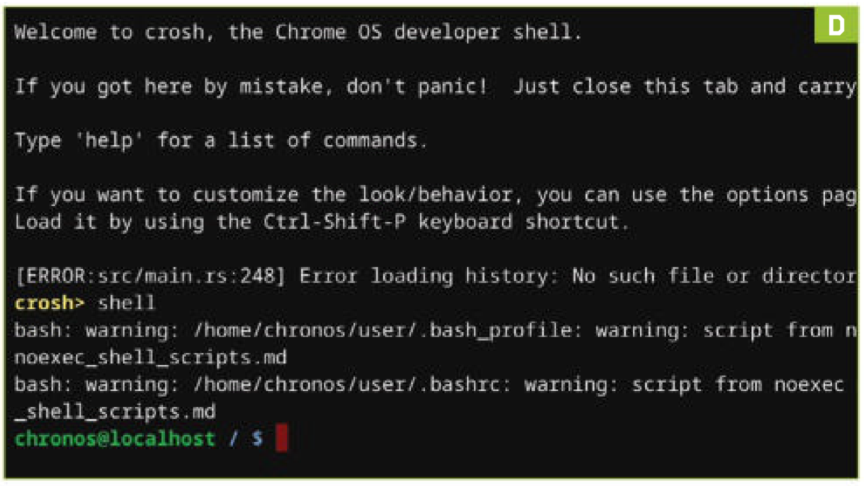


```
Welcome to crosh, the Chrome OS developer shell.

If you got here by mistake, don't panic!  Just close this tab and carry

Type 'help' for a list of commands.

If you want to customize the look/behavior, you can use the options pag
Load it by using the Ctrl-Shift-P keyboard shortcut.

[ERROR:src/main.rs:248] Error loading history: No such file or director
crosh> shell
bash: warning: /home/chronos/user/.bash_profile: warning: script from n
noexec_shell_scripts.md
bash: warning: /home/chronos/user/.bashrc: warning: script from noexec
_shell_scripts.md
chronos@localhost / $ 
```

We tried Microsoft Office Online too, and while it worked, it was an altogether slower experience.

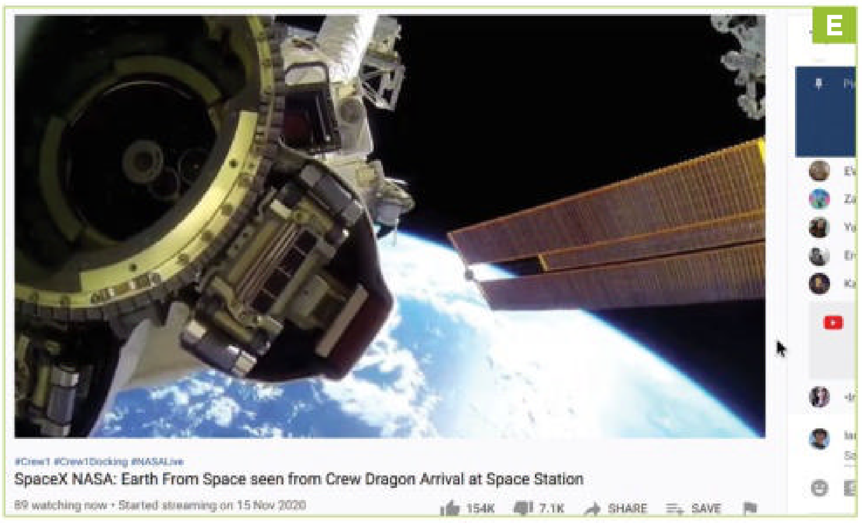
›› A Chromebox is very much an online entity, with little local storage, so you'll need to get used to storing documents in the cloud—especially as there's such a small amount of local storage included. If you find you need to increase the amount of storage available to the Chromebox, you can expand the filesystem to the full size of the card through the developer shell. Press Ctrl + Alt + T from the desktop, and a browser tab will open containing crosh. Type "Shell", and you'll be in Bash [**Image D**]. Type "sudo rm /mnt/stateful_partition/.autoexpanded" and reboot the OS.

5 MEDIA

You'd expect browser-based streaming services to be accessible through Chromium OS, but they're hit and miss. Being a Google project, YouTube is of course prominent, and we were able to watch a SpaceX capsule arrive at the International Space Station live and without jerkiness [**Image E**]. Attempting to watch hilarious Eddie Murphy movie *Coming to America* on Amazon Prime, however, failed on every attempt with an unhelpful error. *The Matrix Revolutions* failed in the same way, but admittedly felt like less of a loss. This was due to the Widevine DRM system for Chrome not being supported in Chromium OS. There's a way around it, which is linked to from the "Issues" page of the Chromium OS for Raspberry Pi Github.

6 SETTINGS AND SHORTCUTS

The Settings app is the blue cogwheel icon in the dock, and opens into a comprehensive set of options for your device. It's where you go to connect to a new Wi-Fi network, add a new user to the Chromebox, or pair a new Bluetooth device, as well as adjust the screen resolution and scaling. On a 4K display, we found things much easier to use if we boosted it up to 175 percent of the usual scale. Settings also contains options for personalization (see the box) and, under the "Apps" heading, you can choose which apps are pinned in the dock. Some, like Photopea, open in their own windows, while others, such as Google Drive and Canva, open in a browser tab.

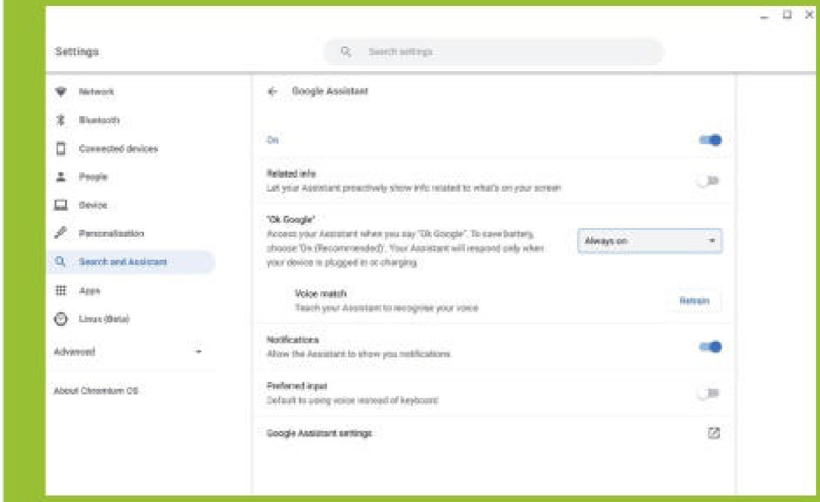


#Crew1 #Crew1Docking #NASALive

SpaceX NASA: Earth From Space seen from Crew Dragon Arrival at Space Station

89 watching now • Started streaming on 15 Nov 2020

FURTHER ADVENTURES IN SETTINGS



On

Related info
Let your Assistant proactively show info related to what's on your screen

"Ok Google"
Access your Assistant when you say "Ok Google". To save battery, choose 'On (Recommended)'. Your Assistant will respond only when your device is plugged in or charging.
Always on

Voice match
Teach your Assistant to recognise your voice
Retrain

Notifications
Allow the Assistant to show you notifications

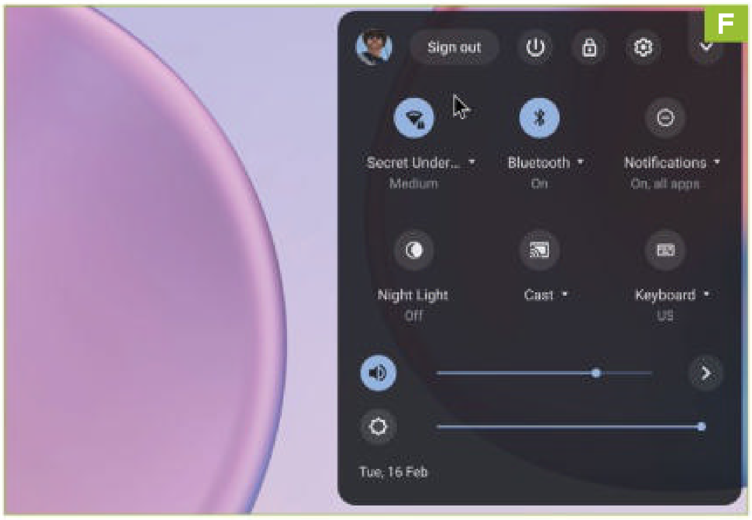
Preferred input
Default to using voice instead of keyboard

Google Assistant settings

You can connect a mouse or touchpad to the Pi. Touchpad use is almost exactly the same as in Windows. Tapping with two fingers gets you the right-click menu, and scrolling involves dragging two fingers down the pad. If you want to reverse this, there's an option in "Settings → Mouse," from where you can also adjust the pointer speed. Pressing the Windows key brings up the Launcher, from where you can choose between recent applications or search for a new one, and there's a circle button in the bottom-left corner that does the same thing. "Settings → Keyboard" contains a great many options for mapping a Windows keyboard to the Chromebook standard, enabling you to change the behavior of Ctrl, Alt, Esc, Backspace, and more. Finally, Google Assistant can be activated, but is off by default, as Raspberry Pis don't have a built-in mic. Add one, plus speakers, and you can turn your Pi into a digital assistant.

7 QUICK SETTINGS AND POWER

Click the gray lozenge at the bottom-right corner, and you'll get a pop-up menu with quick settings, such as turning Bluetooth on and off, changing the volume, locking the screen, and turning the system off [**Image F**]. Being a Raspberry Pi, the unit does not have the ability to switch itself off, so you'll have to cut the power yourself once the OS has finished shutting down. Most Raspberry Pi kits come with a handy switch on the power supply lead for this purpose. ⏻



Emulating the Commodore 128

YOU'LL NEED THIS

ALMOST ANY PC
Very little. Almost any PC will be catered for, we'll focus on Windows and Linux. You won't need any system ROMs – the emulator comes with a BIOS.

VICE
https://vice-emu.sourceforge.io/

SO FAR we've been covering home computing's big hits, but we also want to highlight some of the more under-appreciated computers, in the hope that we can generate more interest toward these retro machines.

This month we're covering the Commodore 128, the underrated follow-up to the phenomenal Commodore 64. Although there's plenty of business and desktop software for the machine, very little exists in the way of native games or demos.

We hope to change that. The Commodore 128 provides a great opportunity for any C64 coders who want to enhance their existing titles with extra features and content.

After we take you through a brief history of the machine, we will show you how to emulate it. With any luck we can inspire you to learn the machine's workings, and go on to code new games and demos! –**JOHN KNIGHT**

1 DEVELOPMENT

Commodore's final eight-bit machine, the C128, was developed as a halfway point between the Commodore 64 and the Amiga, intended to capture sales in the low-end business market. For the follow-up to the C64, Commodore listened to the demands of the press and stuffed the 128 full of features.

» System RAM doubled to 128KB. There were two CPUs: a MOS Technologies 8502—an improved version of the C64's 6510, capable of twice the clock speed—and a Zilog Z80 CPU, the processor that ran many of the C64's rivals.

» A number pad was added to the keyboard, along with an 80-column text mode. The 128's BASIC was significantly improved, with more advanced programming structures, making the most of the 128's doubled RAM capacity. There was also a machine-language monitor and an in-built sprite editor, allowing freehand drawing of sprites that could be stored on disk.

» The 128 had more reliable disk drives that were 11 times faster than the C64's, with double-sided heads, removing the need for disk-flipping. Furthermore, the new drives could read other formats, such as MS-DOS, and had automatic disk booting, so users no longer had to enter load commands in BASIC.

» Crucially, the 128 was 99 percent backwards compatible with the Commodore 64 and its enormous software library. Thankfully the 64's legendary 6581 SID sound chip was unchanged.

2 WHAT WAS IT LIKE TO USE?

From a gaming perspective, underwhelming, but from a business perspective, great. The 128 was focused on desktop productivity. Without hardware sprites or raster interrupts, the 80-column VDC chip was all business and not much use for gaming. On the upside, the new version of BASIC had graphical improvements, removing the need for POKE commands, and enabling users to easily create sprites.

» Gaming was basically left to the machine's C64 compatibility mode, which could be accessed by holding down the Commodore key at startup, entering "GO 64" at the BASIC prompt, or starting the machine with a C64 cartridge attached. After the 128's release, most Commodore 64 games were advertized as being "Commodore 64/128 compatible."

» When running in C64 mode, most of the 128's extra functions were disabled, though the machine's 2MHz CPU mode was still available, and some games took advantage of this ability, like *Elite 128*. Games that used the 128's native mode often enhanced existing C64 titles with extra levels and content, such as *The Last V8* (1985) and *Kikstart 2* (1987). *Ultima V* (1988) added a soundtrack and used the 128's faster disk access. Many titles were simply text adventures that took advantage of the 80-column mode.

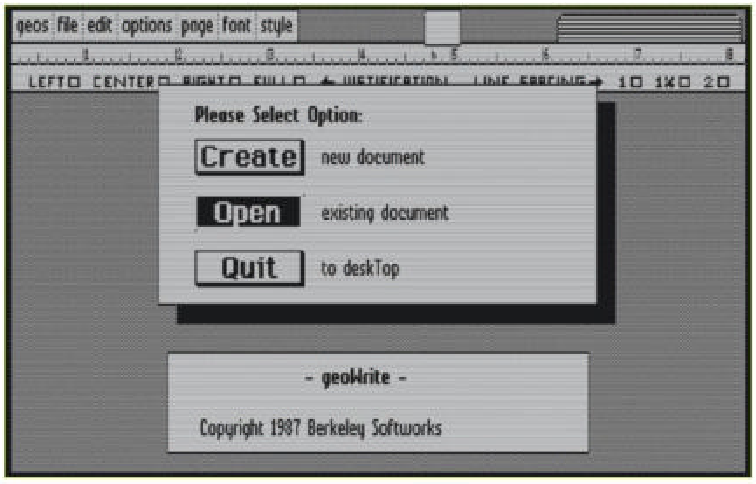
» Weirdly, the 80-column mode required a second monitor, though Commodore released a special monitor with dual inputs and a switcher for choosing modes.

3 DOWN TO BUSINESS

Thanks to its Z80 CPU, the 128 was CP/M compatible—a long-established software ecosystem popular with businesses. Unfortunately, the 128 ran most CP/M software slower than other systems, meaning its CP/M compatibility was largely ignored.

» Instead, 128 owners preferred GEOS 128: a graphical desktop originally created for the C64, but greatly enhanced for the 128, using its extra power and features. GEOS was similar to macOS and came with productivity tools like a word processor and paint program. The 128 version used a high-resolution 640 x 200 display mode, helping establish the 128 as a serious business machine.

» By the time the C128 was discontinued in 1989, it was no longer economically viable to produce. Manufacturing costs were too close to the Amiga 500, and cost-reduced models of the C64 were still selling strongly, especially in Europe.



Please Select Option:

Create new document

Open existing document

Quit to deskTop

- geoWrite -

Copyright 1987 Berkeley Softworks

» **Although the C128 wasn't a popular games machine, it was a well-loved desktop when paired with GEOS 128.**

© 1986, BERKELEY SOFTWORKS

» Although largely forgotten by retro gamers, the Commodore 128 supercharged the C64 and still outsold many rivals.

» With 5.7 million units sold worldwide, the 128 never reached the dizzying sales of the Commodore 64, but it was still a success in its own right and outsold most other microcomputers.

4 HOW DO I EMULATE IT?

Our main choice of emulator is VICE, which supports Windows, Linux, Mac, and many obscure platforms. VICE is known primarily for emulating the C64, but supports all eight-bit Commodore machines, including the 128.

» For the Windows version, head to the website and download the latest build. This package uses the 7-Zip format, so you may need a separate application for that. VICE doesn't come with an installer, so after extracting the package, you'll have to go into the new folder, open the <i>bin</i> folder, and manually open x28.exe. You might want to make a desktop shortcut.

» For Linux users, VICE is available in the repositories but will probably be missing key "kernal" files due to licensing restrictions. You can get these files from a source tarball, but it's much easier to install a Snap or Flatpak package instead. Both versions should install entries in your system menu.

» Snap users can find the package on the Snapcraft store under the name vice-jz. If you prefer Flatpak, you can install VICE with the command:

```
$ flatpak install flathub net.sf.VICE
```

5 USAGE

As soon as VICE-128 is opened, the first thing that hits you is a two-window setup: one is for the older C64 40-column display, the other is for the newer 80-column display.

» The old 40-column display is used for the initial load commands, but then a native 128 title may switch to the high-res display. Meanwhile, the 40-column display will give you a message to switch to 80-column mode—with VICE that just means switching to the other window!

» The easiest way to load something is by clicking "File→Smart attach disk/tape." Choose your file, and click "Autostart." If you get stuck with the BASIC prompt saying "LOADING, READY," type "RUN" and press Enter.

» Before you get started on any games, you should define how you will use joysticks: whether they be keyboard emulated, or by an external device. From the system menu, choose "Input devices→Joystick settings." You need to define the method for two ports: most games use joystick port 2, so whatever you intend to use most, set that keyset or joystick to use port 2, and have your backup on port 1. Don't forget to save your configuration by clicking "Settings→Save settings."

» If you encounter any 3.5" floppy images (which may have a .D81 file extension), you'll need to change the type of disk drive. From the system menu, select "Settings→Settings→Peripheral devices→Drive." Make sure "True drive emulation" is enabled, and change "Drive type" from the default setting of CBM 1571 to CBM 1581.

FINDING SOFTWARE

We generally point to archive.org first, but there's not much actual C128 software. However, it is full of user guides, programming manuals, and BASIC program listings if you're willing to get stuck in and write something new.

For actual software sources, a great place to start is the "C-64 Scene Database" at csdb.dk. Enter "128" in the search box, and you can find a good listing of games, demos, and utilities for the 128.

Anyone looking specifically for demos should check out https://demozoo.org/platforms/55/. There are some games thrown in as well, with some software as new as 2020.

However, the best resource has to be the forums at c-128.freeforums.net. Here you can find new games and demos, and chat all things Commodore.

Commodore 128 software usually comes on disk, though these files are unhelpfully still given the extension ".d64" – don't mix your 64 and 128 files into the same folder!

SPECIFICATIONS

COMMODORE 128 (1985)

CPU:	MOS Technology 8502 @ 1-2MHz
RAM:	128KB
Launch price:	$595
Graphics:	VIC-II E 320x200, 16 colors, MOS 8563 640x200, 16 colors
Sound:	SID 6581
Storage:	Cassette, 5.25" floppy, 3.5" floppy, and cartridge
OS:	Commodore BASIC 7.0, Digital Research CP/M 3.0, GEOS 128
Released:	January 1985
Production:	1985-1989
Worldwide sales:	5.7 million

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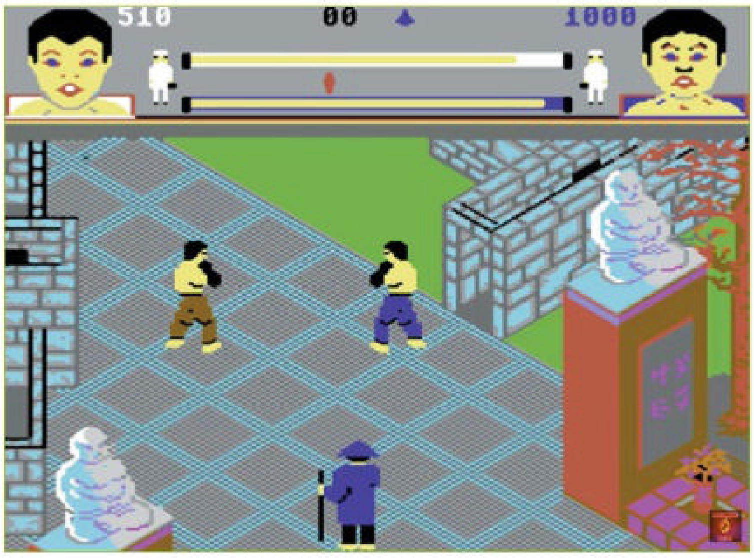


» Games like *Thai Boxing* (1986) were part of the small list of games that used the 128's native mode, rather than using C64 compatibility.

LAB NOTES

TESTED. REVIEWED. VERDICTIZED.

Worrisome Wireless Woes

Wireless mice just aren't really wireless anymore

WIRELESS MICE are becoming increasingly popular as the tech advances, and latency issues are a thing of the past now for most high-end wireless mice. In fact, the majority of mice we receive are either ultra-light wired mice, or their heavier wireless brethren, with massive battery, charging cable, and optional magnetic parts.

When I read the word "wireless" something inside me makes me think that it's without a wire. I am not sure what stirs up these emotions, it will likely stay a mystery forever—you know, apart from the fact it's called "wireless." So, why is it that after a hard week's work, I log onto a fast-paced game to frag some noobs, and then get hit with a "please charge your mouse" warning? I now must move myself slightly, find the darn cable, plug the mouse in via the cord, and then charge it like a savage while I use it, completely defeating the point of the mouse. It's probably the reason why I can't become a pro gamer—definitely not my lack of speed, skill, and attention span. It is 100 percent that wire.

It doesn't need to be like this, however. Logitech, Corsair, HyperX, Razer, ASUS, and other brands all have wireless charging mice. They're just few and far between. They charge by just being on a mousepad—magic right? I haven't plugged my Logitech G903 in since the day I purchased it. But as I'm usually using a review sample, often it's pushed to the side while I play my "Will I have to plug in the mouse today, in the five minutes I get to relax before Zak makes me write something?" game. (Catchy name, right?)

Please, manufacture more mice with Qi charging or similar! I understand that they're more expensive to produce, and I also understand that you must slap us with a crazy-priced mousepad as well to make that happen, but I can't take it. Heck, the more they're made available, the cheaper they will become anyway. **–DA**

The Logitech G PowerPlay offers actual wireless use.

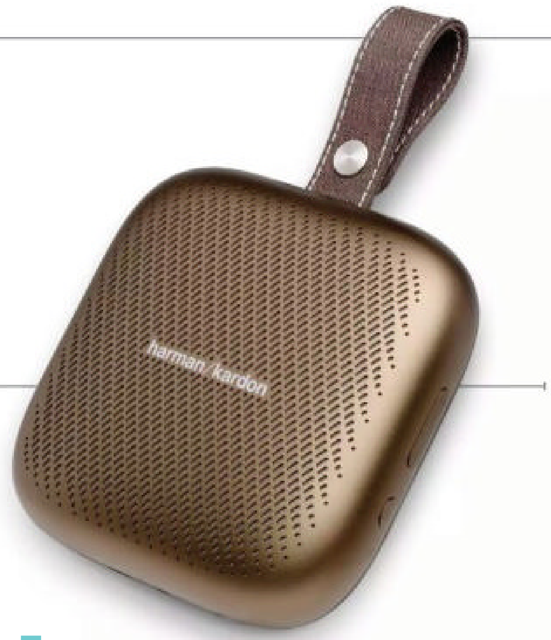
ZAK STOREY

Editor

It's nice sometimes to just be surprised and proven wrong. I love it. It's why I like to be corrected, and why I like to be wrong as well. Making mistakes is the best way to learn something. And nowhere is this more true than preconceived opinions in tech.

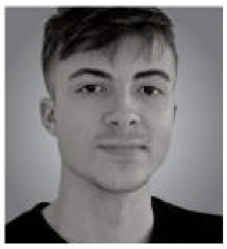
In my case, I've had the luxury of using an AMD Radeon 6800 XT now for about two weeks or so. I'm holding onto that 4K gaming PC from last issue for as long as I can (sorry AMD, you can't have your card back yet). I'm just blown away, not only by the performance, which is what you'd expect from the latest generation of cards (outside of ray-tracing, which I use in all of one game), but also by the software. AMD's Radeon Software is genuinely a breath of fresh air. After having to use GeForce Experience for far too long, this thing is extraordinary. The UI is slick, it measures average frame rates in the games you've played, lets you know your driver status, looks at your specs and recommends updates, enables you to tweak and tune your GPU, makes streaming easy, and best of all, doesn't require a login, password, or CAPTCHA.

The last time I used AMD GPU software was with the AMD Radeon Fury X, and it's nice! When I first set up this rig I thought, "Nah, AMD's GPU software has always been a bit meh," but this has genuinely changed my stance. Good work AMD, keep it up. And Nvidia, take note.



Editor's Pick: Harman Kardon Neo Speaker

Budget portability doesn't have to be poor quality



AUDIO DEVICES are something that I have always been excited about. Any chance I have to myself, I find I'm listening to music, whether that is through a pair of headphones or a speaker. Due to old age, I presume, it's sad to say that my beloved Bose SoundLink Mini Bluetooth speaker is on its way out. I got six years out of it, and a tear was shed when I knew I had to change. Unfortunately, I'm not at a place where I can have my dream home speaker setup right now, so to bide my time I thought I'd see if I can find an equally good speaker for cheaper—for me, the Bose speaker suited my needs of sound quality and portability perfectly. That's when I found this quirky Harman Kardon Neo.

Harman Kardon is a brand I have liked for a while, so I thought I'd see what it has to offer in the small Bluetooth speaker market. I'm more than happy with what I got for the price. Harman Kardon has done what a lot of brands seem to fail at, when introducing a budget device: it has maintained its quality. A lot of corners get cut when it comes to the materials used in budget devices like this, but the Neo is finished in a brushed-metal top half and a rubberized base. It feels strong and premium to the touch, compared to others in its class. At the top, there's a tough fabric loop that's buttoned. Features like this are a nice touch for portability, enabling you to hang it off a bag, or hook it onto anything imaginable. Its palm-size dimensions push that impression of a premium portable device. It's also IPX7 waterproof—though I am always skeptical about this, and try to avoid electric meeting water at all costs.

On the left side of the speaker are the power and Bluetooth buttons, which are firm and clicky, allowing you to feel when you've pressed a button. It sounds odd, but I like a good tactile click on something like this. On the right, you have the volume and play/pause buttons. You can double-tap the play/pause button to skip a song—handy when you realize you have no idea where you've put your phone. Connectivity is good too, as the device supports aux input on the bottom, as well as Bluetooth. It's charged via USB-C, and boasts 10 hours of battery life. It also supports the ability to take calls from the speaker with an "echo-canceling" speakerphone, which works effectively.

The sound is pretty darn good considering it's a small 3W speaker. It's not as good as my beloved Bose SoundLink Mini, but that is a larger, more expensive device. Mid to higher volumes is where the punch seems to come through. It can get loud enough for an average-sized room in the house, and for when things get back to normal, small outdoor gatherings, such as in a garden. However, you wouldn't necessarily use it for larger gatherings like a party, as it'll get drowned out.

At lower volumes the speaker loses clarity and seems compressed. And when it's not playing music it hums slightly. But it can get quite bassy and is well balanced, only suffering a little in the trebles. The sound is nothing to write home about, but from where it sits in the market, at under 100 bucks, it's not a cop-out by any means.

Overall the Harmon Kardon Neo maintains the brand's quality image and design style at a budget price. The sound quality is good too. It certainly feels more expensive than it costs. It's a good buy for me and someone looking for a very portable and stylish speaker to throw in a travel bag from a high-end brand. I will certainly be taking it everywhere with me. **–SL**

$42.99 www.newegg.com

© HARMAN AUDIO, NOBLECHAIRS, NORTON, IO INTERACTIVE

Reviewed...

74 AMD Ryzen 9 5950X

76 Razer Book 13

78 Lenovo Q27H-10

SAMSUNG
Solid State Drive

80 1TB Samsung 870 EVO SSD

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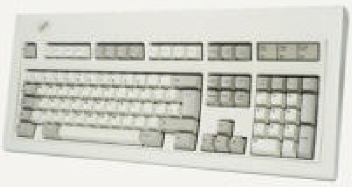

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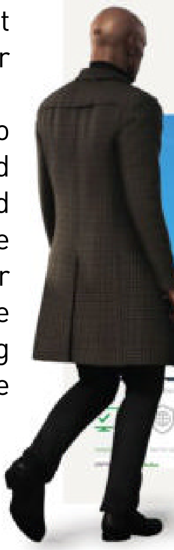

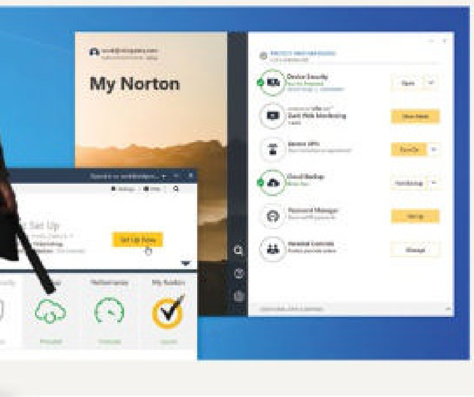

AMD's successive iterations have led to one astounding processor.

AMD Ryzen 9 5950X

The usurper has come

OKAY, LET'S START with what might be a bit obvious. At the time of writing, you cannot buy this processor anywhere. Not in the US, or Canada, or the UK, or Europe, or Australia—at least not at its retail price. There are a few popping up on eBay and similar sites every now and then, and some scalpers are selling them for $400+ on top of the original retail price, but outside of that, if you want the latest and greatest Ryzen processor for the price it was intended, well, you can't.

We've waxed lyrical about how stocks have dwindled across the entire tech sector over these last few months, and sadly it's the case with the 5950X. A combination of things have led to this moment. The pandemic is an obvious one, as more folk stay at home; fab time is now limited as more and more companies vie for their products to be manufactured first; then there's the fact we've got a new generation of consoles taking up valuable chips, new cars with all manner of tech inside, new GPUs, and of course crypto-mining is on the uptick again as well (thanks Elon). The list is endless, but regardless of which thing has done the most in that long string of events, the outcome is the same: There isn't any stock, and there hasn't been since shortly after the 5000 series launched. And that's a shame, because this processor is unlike anything we've seen before.

LONG LIVE THE KING

We've had the luxury of using this thing now for three weeks as our daily driver, and the sheer performance it has is just insane. Take Cinebench R15 as a prime example. Retesting this processor after a BIOS update led us to achieve an impressive 4,312 points in multi core, and a staggering 269 points in single core. That's just crazy. The Core i9-10900K, long regarded as the king of single-core IPC, achieved just 228 points in single thread, and 2,608 when it came to multi-core operations. Admittedly that's a 10-core, 20-thread processor, versus the 5950X's clearly supercharged 16 cores, but you can't ignore that kind of figure.

Couple that pure brute strength performance with a redesigned cache layout and better memory operations and latency, and what you're left with is a Ryzen processor that is a true tyrant of a chip. In fact, that might be an understatement. No matter what you throw at this thing, it's going to come out on top. The only areas where it's really held back are in programs where more memory bandwidth (quad channel and beyond) is king, and in that field, the only competition it has is its own siblings, the third-gen Threadrippers.

We were there at the launch in San Fran when Ryzen first debuted in 2017, and it was amazing to see. However, it was flawed—it had memory problems, BIOS issues, and a slow single core. The big selling points were the multi-core performance, and the price. The second generation appeared in 2018, improving on the memory latency and single-core performance, but it still wasn't super-slick. Then the third gen came along in 2019, and with it we saw PCIe 4.0 for the first time, and even better single-core performance, but the chips were hot, power hungry even under the best liquid-cooled solutions, and Intel was still slightly better for IPC. Now though? This is the pinnacle of what we've seen so far. The Ryzen 9 5950X is perfectly balanced. Its performance is staggering—memory issues are a thing of the past, temperatures remain under 70 C even under intense load, and for the first time really since its inception, it's finally unseated Intel as the gaming chip of choice. Its only flaw is a lack of stock.

The Ryzen 9 5950X is awesome, it's powerful, and yet it's absent. Maybe we'll see it come summer and fall, but for now, it's like a leaf on the wind—all you can do is watch how it soars. **–ZAK STOREY**

VERDICT
9
KICK ASS!

AMD Ryzen 9 5950X

+ **TYRANNICAL** Incredible performance; decent temperatures; good gaming figures; overclocking headroom.

– **TYPICAL** Lack of stock.

$799 www.amd.com

BENCHMARKS

	AMD Ryzen 9 5950X	Intel Core i9-10900K
Cinebench R15 Single (Index)	**269**	228
Cinebench R15 Multi (Index)	**4,312**	2,608
Tech ARP's x264 (avg FPS)	**91.84**	54.64
Fry Render (m:s)	**0:49**	1:23
Total War: Warhammer II (fps)	**84**	81
Ghost Recon Wildlands (fps)	58	**59**
Maximum Overclock (GHz @ V)	4.6 @ 1.28V	**5.3 @ 1.36V**
Price Per Thread	**US $25**	US $27
Recommended Retail Price	US $799	US $530

Best scores in bold. AMD test bed consists of an Asus ROG Crosshair VIII Dark Hero, 32GB of Corsair Vengeance RGB Pro DDR4 @ 3200, and an Nvidia GeForce GTX 1080. All games were tested at 1080p on the highest graphical profile, with average fps noted. Intel motherboard is the MSI MEG Z490 ACE.

SPECIFICATIONS

Cores / Threads	16 / 32
Base / Turbo Clock	3.4 / 4.9 GHz
Architecture	Zen 3
Lithography	TSMC 7nm
Memory Support	DDR4 @ 3200
PCIe Support	PCIe 4.0 x24 (x16x4x4)
Integrated Graphics	N/A
TDP	105W

Razer offers a premium edge in the ultrabook market.

Razer Book 13

A new chapter

RAZER, KNOWN FOR its high-performance hardware, has offered a change in direction from its usual gaming-focused machines here. The Razer Book 13's selling point is performance meets productivity. So, being a bit out of Razer's comfort zone, how does this ultrabook make a mark on the productivity world? Well, there are three models of the Book 13—we have the range-topping model with a quad-core 11th-Gen Intel Core i7-1165G7, and a UHD touchscreen display.

Let's get straight into that display. For productivity and general usage, it's an extremely crisp panel. Colors pop on the 13.4-inch screen, and at 60Hz it looks smooth, though it's not the best for gaming. The panel is 16:10 with a resolution of 3,840 x 2,400. This creates a tight PPI density of 338 for excellent detail, while the aspect ratio gives you a little more vertical real estate on your screen. You'll be able to see more on a page, which helps in the productivity sector. It is a very responsive touchscreen display, but you'll likely have to scale things up, as it can get fiddly with the tiny icons. The screen also fits the chassis perfectly, with tiny bezels all around.

The overall look of this ultrabook is exactly what you'd hope Razer would produce to make a stamp on this corner of the market. Razer's switched away from its traditional gaming-focused black and green designs to a mercury color design with a minimal chrome logo, and a light all-aluminum unibody design with no chassis flex. It's nice and sturdy to hold, has a cool feel to the chassis, and it avoids being a fingerprint magnet. The design is boxy, but due to how thin it is, it still feels sleek and premium. Dare we say it, the finish is MacBook quality. One tiny complaint is that it can be quite a pain to open with one hand—a slightly larger groove on the opening mechanism would have sorted this out.

The keyboard is superb and very easy to type on. The keys have low travel but are springy, making them nice and responsive. Keys are individually backlit with Razer Chroma RGB, so you can customize them how you want. The trackpad is also impressively sized considering it's a 13-inch ultrabook. It feels well-built, with no movement, and it's very accurate and responsive. You are always going to want to use a mouse if you can, but if you're on the move then the trackpad is more than good enough.

The Razer Book 13 is also good for connectivity. It has two Thunderbolt 4 USB-C ports, one on each side. It should be standard for all laptops to have charging on both sides, as it's really convenient. On the right side, you get a USB-A port, along with a 3.5mm headphone port. On the left, you also get an HDMI 2.0 port and MicroSD card reader. A standard SD card reader would probably be preferred here, especially by photographers.

PAGE-TURNER

All good so far, but how does the Razer Book 13 run? For day-to-day laptop internet use, it runs perfectly, handling browsing and procrastination easily. Communication is top tier—the integrated webcam is clear, providing you have a well-lit room, paired with four microphones, making it great for meetings. With the superb display and the extra real estate, you can use the Book 13 for ages with no struggle.

The performance is very reliable, and using Adobe products on this tiny ultrabook is no problem at all, nailing its USP. With 16GB of RAM, you can have lots of tasks and tabs open simultaneously with little struggle. Running on Intel's EVO platform, it's very responsive, with one-second instant wake, quick charging that gives you four hours of usage in 30 minutes, and Intel Wi-Fi 6 for great internet connectivity.

Battery life is very good, lasting for a full day's work. However, the storage isn't perfect, with 512GB being the maximum option. It's also not great when it comes to gaming—though it's not designed for this, as Razer already has that sector covered with its other products.

On the whole, then, the Razer Book 13 is a great productivity ultrabook, and Razer has targeted the likes of the Dell XPS 13 and maybe even the Mac lovers out there who can be tempted over to the Windows life. For its remit it is great—communication is excellent, and the whole package is very premium, leaving a mark on the productivity laptop market.

Unfortunately, it's not quite the whole package, especially since gaming isn't really for this ultrabook. Also, only 512GB of storage is offered when more will be needed for productivity purposes, which is rather disappointing. For its price and purpose, however, the experience is exceptionally premium. **–SAM LEWIS**

VERDICT

9

Razer Book 13

+ MAKING A MARK Great premium design; gorgeous rich UHD display; perfect for productivity.

− SO CLOSE Needs more storage; not great for gaming.

$1,999.99, www.razer.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	**1,030**	802 (-22%)
CrystalDisk QD32 Sequential Read (MB/s)	3,374	**3,540** (4%)
CrystalDisk QD32 Sequential Write (MB/s)	2,530	**2,978** (15%)
3DMark: Fire Strike (Index)	**13,610**	4,849 (-64%)
Rise of the Tomb Raider (fps)	**92**	21 (-77%)
Total War: Warhammer II (fps)	**62**	31 (-50%)
Tom Clancy's Ghost Recon: Wildlands (fps)	**49**	21 (-57%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	11th Gen Intel Core i7-1165G7 Quad-Core Processor
Graphics	Intel Iris Xe Graphics
RAM	16GB dual-channel (fixed)
Screen	13.4" 4K UHD @ 60Hz
Storage	512GB SSD
Ports	1xHDMI, 1x USB 3.1 Gen1 Type-A, 2x Thunderbolt 4 USB Type-C, 1x 3.5mm combo-jack, 1x MicroSD Slot
Connectivity	Intel Wi-Fi 6 AX201, Bluetooth 5.1
Weight	3.09 lbs
Size	0.6 x 7.8 x 11.6 inches

Lenovo Q27H-10

USB Type-C connectivity for a reasonable price

EXPERIENCED the sweet simplicity of single-cable USB Type-C? Then you won't want to go back to the rats' nest of cables running between your laptop and monitor that is conventional display-and-peripheral connectivity. It's a pity, then, that USB-C tends to add a lot to the price.

Until recently, that is. The new Lenovo Q27H-10 is one of a new breed of more affordable USB Type-C enabled screens. On paper, it ticks an awful lot of boxes. There's a quality IPS panel, quad-HD 2,560 x 1,440 pixel resolution, slim-bezel design, and the reassurance of one of the best brands in computing.

Indeed, with pricing that's been as low as $259, the Lenovo Q27H-10 looks good value even without USB-C docking. As we write, the price has jumped up to $299, which probably reflects supply line shortages blighting the whole tech sector.

Inevitably, however, that affordability comes with certain limitations. For starters, this is not a monitor aimed at serious content creators who need extensive color coverage. Lenovo doesn't even quote coverage of either Adobe RGB or DCI-P3, only indicating that the Q27H-10 is good for 99 percent of the sRGB gamut. Indeed, sRGB is the only standardized gamut preset offered by the OSD menu.

Similarly, you don't get any kind of HDR support. Of course, most monitors that claim HDR capability don't live up to that. There are few PC monitors with proper local dimming capability. So we prefer this monitor's straightforward honestly.

What you might not appreciate quite so much is the tilt-only stand. It's a slightly odd limitation given that the super-slim bezels and slick chassis look and feel like a big bucket of bitcoin. This monitor has the desk presence of something twice the price, and it doesn't give the impression of corner-cutting in any other regard.

The rest of the detail specifications include 350cd/m2 of claimed brightness, 1,000:1 contrast, and 4ms response performance. As for refresh rate, at this price point, and given the unambiguous productivity remit, you shouldn't be surprised to learn that we're talking 60Hz.

Rounding out the speed and feeds, the aforementioned USB Type-C interface supports up to 65 watts of charging power for your laptop, which is adequate but won't be able to keep a really powerful desktop replacement fully juiced under heavy load. Conventional DisplayPort and HDMI connectivity is also provided.

But what of image quality? This is unapologetically an SDR panel with limited color coverage, and thus it comes with relatively modest expectations. Even then, it slightly undershoots in terms of pure punch and vibrancy. Subjectively, the experience is not quite what you would expect from a 350cd/m2 panel. It is, however, a pretty well-calibrated screen, with natural tones and a neutral color temperature. The only obvious exception is a little compression in darker tones where some detail can be lost. But that's being very critical in the context of this panel's remit. Only serious content creators will likely be bothered by that limitation.

Elsewhere, you get excellent viewing angles and good if not outstanding contrast. Then there's pixel density. At this price point, you could have a cheap 4K panel without USB-C connectivity. That would make for sharper text and more detail, but worse connectivity and desk ergonomics. Ultimately, you make your choice with that. If you want 4K and USB-C in a single screen, you'll pay far more.

As an all-round proposition, then, the Lenovo Q27H-10 has plenty of appeal. If you're happy with QHD, this is a nice monitor for the money. –**JEREMY LAIRD**

VERDICT **9**

Lenovo Q27H-10

+ SUPERCHARGED USB-C docking; decent IPS panel quality, gorgeous build quality.

− OVER CHARGED Tilt-only stand; could be brighter.

$299 www.lenovo.com

SPECIFICATIONS

Panel type	IPS
Resolution	2,560 x 1,440
Brightness	350cd/m2
Contrast	1000:1
Pixel response	4ms
Colour coverage	99% sRGB
Refresh rate	60Hz
Vesa	100mm x 100mm
Inputs	DisplayPort 1.2, HDMI 1.4, USB-C with 65W charging

Lenovo's new 27-incher delivers up to 65 watts of charging power over USB Type-C.

1TB Samsung 870 EVO

Can Samsung teach old SATA new tricks?

IS THERE ANYTHING left in the tank when it comes to solid-state drives based on ye olde SATA interface? It's a reasonable question, what with the obvious limitations of what is a positively antiquated interface.

After all, the latest M.2 PCI Express Gen-4 drives have around 8GB/s of theoretical bandwidth to play with. SATA is pegged at a mere 600MB/s. That's just raw bandwidth. SATA also makes do with an elderly control protocol called AHCI, which was conceived with spinning magnetic platters, not NAND memory chips, in mind. The latest M.2 drives run the solid-state-optimized NVMe protocol.

All of that probably explains the roughly three-year interval between the new Samsung 870 EVO and its 860 EVO predecessor. In between, we've had the 870 QVO, of course. But as its name implied, the QVO is based on quad-level QLC NAND memory chips, which come with some significant limitations.

The new 870 EVO, by contrast, sticks with faster and more expensive TLC triple-level cells. And yet the question remains: does SATA have anything more to offer? On paper, the new 870 EVO has Samsung's latest 128-layer TLC memory chips. It also packs the latest Samsung MKX SATA controller, as first seen in the 870 QVO. Elsewhere, there isn't evidence of dramatic change. You still get 1GB of cache memory on this 1TB model, and just like the 860 EVO, the range goes all the way to 4TB.

BARKING UP THE WRONG TREE?

Samsung isn't exactly effusive when it comes to the technical changes that the 870 EVO, its new NAND chips and MKX controller bring. But a 38-percent improvement in queue depth on random read latency is on the list. All told, however, the changes don't bring much by way of immediate and obvious benefits to the quoted performance metrics. Peak reads remain at 560MB/s, exactly the same as the 860 EVO, while writes top out 10MB/s higher at 530MB/s.

Claimed random read IOPS performance, meanwhile, is actually fractionally lower, with the 870 EVO rated at 98K to the 860 EVO's 100K. Random write IOPS are likewise a tiny bit down from 90K IOPS to 88K. As for endurance and warranty, it's all the same. Once again, cover extends to five years and 600TB of writes.

But what of actual, independently tested performance, as opposed to Samsung's claims? The harsh reality is that this new drive does little to up the SATA game. In the one area where you might hope for some clear gains, namely 4K random access, the new 870 EVO is actually pretty patchy.

It's slower across the board than the old 860 EVO by that measure, albeit the comparison isn't quite like-for-like as the 860 EVO reference drive-tested was the 500GB variant. Even so, we found the 870 EVO to be inconsistent under 4K testing, with performance varying significantly from one run to the next. Peak sequential throughput, meanwhile, was virtually identical to the old 860 EVO.

One aspect that has changed hugely since the 860 EVO was launched, however, is price. Back in 2018, the 860 EVO 1TB launched at $329.99. This new 1TB 870 EVO arrives at a recommended price of $129.99. That's a pretty spectacular improvement, especially when you compare it to spiralling prices for other components, such as graphics cards.

In most technical regards, then, the 870 EVO barely registers a flicker. Overall, it might actually be the slower drive—but not to any extent that you'd really notice it. Instead, it's best to think of this new SSD as more of a continuation of its predecessor, just priced hugely lower, or at least priced hugely lower compared to the 860 EVO's launch price. The biggest problem for the new 870 EVO is that you can now get an 860 EVO 1TB for around $20 cheaper. While that remains true, we'd recommend opting for the older drive. **–JEREMY LAIRD**

VERDICT **8**

Samsung 870 EVO 1TB

+ NEW AND IMPROVED Way cheaper than its predecessor's launch price; upgraded internals.

– ALL TOO FAMILIAR Performance is not any better; not actually cheaper than an 860 EVO today.

$129.99 www.samsung .com

SSD BENCHMARKS

	1TB Samsung 870 EVO SSD	500GB Samsung 860 EVO SSD
CrystalDisk 6 Sequential Read (MB/s)	**564**	563
CrystalDisk 6 Sequential Write (MB/s)	**535**	533
Anvil 4K QD1 Read (MB/s)	45	**50**
Anvil 4K QD1 Write (MB/s)	117	**119**
Anvil 4K QD2 Read (MB/s)	72	**98**
Anvil 4K QD2 Write (MB/s)	208	**225**
Anvil 4K QD4 Read (MB/s)	131	**182**
Anvil 4K QD4 Write (MB/s)	**327**	314

Best scores are in bold. Our test bench consists of an AMD Ryzen 7 3800X, an Asus Crosshair VIII Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 EVO 250GB OS SSD.

SPECIFICATIONS

Format	2.5-inch
Capacity	1TB
Interface	SATA
Controller	Samsung MKX
Memory type	128-layer TLC NAND
Cache memory	1GB DDR4
Sequential read	560MB/s
Sequential write	530MB/s
Read IOPS	98K
Write IOPS	88K
Warranty	5 years

SAMSUNG
Solid State Drive

Three years after the 860 EVO, Samsung has finally launched a new TLC SATA drive.

It's a fine old case, but it just doesn't stand out.

MSI MPG Gungnir 100

The spear that never misses flies wide of the mark

MSI'S A FAIRLY NEW name in the world of case design. It's had a few different cases pop up every now and then over the years, but it's never seen quite enough success to really cement itself as one of the big players. The Gungnir 100 we're looking at today is perhaps a little insight as to why.

It's got all the trappings of a decent mid tower; tempered-glass panel, full-size PSU cover, decent support for liquid cooling, RGB lighting, SSD caddies, and some fairly acceptable cable management too. However, it's let down in a few key areas.

The thing is, designing a case like this is a surprisingly difficult thing to get right. It's a balancing act essentially between developing the design, tooling up the manufacturing process, picking the right materials, and then catering to the correct portion of the market. With a wide breadth of epic cases already available to consumers from brands with a substantial reputation behind them, cutting out your own slice of the chassis pie can be nigh on impossible—unless you're coming to the table with something remarkably different from what the rest of the fold has to offer.

Think of it like this: if Apple launched an electric car tomorrow, similar to Tesla's Model 3, and you had the choice to buy either, 90 percent of people would go with the Tesla. The reality is, although they're both premium companies, Tesla has been building cars for longer—it's ironed out the kinks, so the products it's producing, you assume, are just at a far higher standard. However, if Apple launched a car with a 700-mile range, and could charge to full in 10 minutes, for the same price, then that percentage would drastically shift over to Apple.

Sadly in this case, the Gungnir feels very much like the first part of that analogy, but with about five percent of the quality lopped off, likely in an attempt to recoup costs from the development.

BLUNTED WEAPON

The materials used feel cheap, the steel absorbs fingerprints easily, the front panel takes up marks like it's made of butter, and the RGB feels lackluster to say the least. The interior follows a similar trend. There's clearly been a lot of market research done: there are some fairly decent cable-management ideas (cable bar and grommets), the PSU cover is there, and there's some seriously impressive cooling support too, or at least mounting space. It also comes with four fans (three non-RGB front intakes, and one rear aRGB fan), along with an eight-way aRGB controller. However, the ventilation is tiny, and it doesn't provide anywhere near what we'd consider adequate enough airflow for those intakes.

And here's the thing: for $95, MSI's really focusing on the wrong things. The included fans and aRGB controller are nice, and the ability to 3D print your own designs onto elements of the case is a positive, sure, but it's not the most valuable element of case design. Quality materials and substantive airflow, balanced with a solid layout, will always win out in comparison, when there's just nothing revolutionary or exciting to really help make it stand out from the pack. For that same $95 you could easily pick up a Corsair 4000D Airflow, or an NZXT H510i, or a Phanteks Eclipse P400A, or a Fractal Design Meshify C, all of which stand out in one way or another in contrast to the Gungnir 100. They either have better airflow, more interesting aesthetic design decisions, better complimentary items, or a combination of all of the above.

Don't get us wrong here, the Gungnir is a decent case. It's good, just not exceptional. And in a market with such fierce competition, there's just nothing standout here that really makes us step back and go, "You know what, I think MSI is onto something." If you're a big fan of MSI, and are willing to overlook the flaws here, then you'll be happy, but if you're not so transfixed on brand loyalty, you might be better off looking elsewhere for your next case. **–ZAK STOREY**

VERDICT
7

MSI MPG Gungnir 100

+ **VALHALLA** Good internal layout; easy to build in; decent liquid-cooling mounting.

− **RAGNARÖK** Poor airflow; mediocre materials; better options at the price.

$95 www.msi.com

SPECIFICATIONS

Motherboard Support	E-ATX (up to 10.7 inches), ATX, Micro-ATX, ITX
2.5 / 3.5-inch Support	2x 3.5-inch, 4x 2.5-inch
Max Radiator Support	420mm front, 360mm roof, 120mm rear
Fan Support	3x 120/140mm front, 3x120mm roof, 1x140mm rear
Dimensions	20.08 x 8.94 x 20.67 inches
Graphics Card Clearance	15.74 inches
CPU Tower Clearance	6.69 inches

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IBM Model M 1990

How does a 31-year-old keyboard hold up in 2021?

THE IBM MODEL M is a classic. First introduced in 1985, it is the successor to the Model F, which is an equally sought-after vintage keyboard, if not more so. The Model F had a more difficult layout, but the Model M changed this and became more user-friendly. The Model M helped to create the modern-day layout—apart from the lack of Windows keys, it's the same layout as any other full-size keyboard. It is one of the very first keyboards, if not the first, to include dual Ctrl and Alt keys, function keys, alphanumeric keys, navigation keys, numeric keys, and indicator lights, just like we see today.

The switches on the Model M make a keyboard enthusiast weak at the knees. They're so satisfying to press, and although they are obnoxiously loud, they're very fun to type on, at least for the person doing the typing. The switches are technically "memchanical," but are seen as mechanical by many due to the way they work. Unlike the capacitive buckling springs of the Model F, these are a buckling spring over a membrane. The switch is pressed, the spring buckles, and this action makes a pivoting hammer contact the membrane sheet and actuate. For those who love clicky, tactile switches, the buckling springs are your endgame. They start off at a somewhat low weight, and increase in intensity until the spring buckles with a satisfying "twhunk" and the switch actuates, all in an instant. For typing, they're really on another level compared to popular mechanical switches.

Gaming on the Model M isn't fantastic. For most games it is perfectly fine, but there are a few major drawbacks. The Model M has 2KRO (key roll-over), just like most membrane boards. This means that you can often only press two keys at a time, so if you want to press W, A, and Ctrl at the same time, the keyboard may detect the keypress as something different, or not at detect them at all. Most modern mechanical keyboards have NKRO, which means that all keys will be detected regardless of how many you are pressing. The Model M wasn't designed for gaming, and as such it isn't going to compete in this category. The Model F has NKRO due to it being a capacitive board, and despite the strange layout it is often seen as superior due to this. We're hopefully going to get our hands on a Model F over the coming months/years, so we will see how relevant it is in the modern world too.

RETRO RELEVANCE

The build quality of the Model M is astounding. 30 years later and it looks and works like it just came from the factory. The hard beige/gray plastic of the case is indicative of the style of PCs back in the 80s. The plastic surrounds a large metal plate, and this plate houses the PCB and gives the keyboard a crazy weight. If you want a keyboard to double up as a bludgeon, this is for you. The keycaps are PBT and have a nice grayscale theme. They're rather good quality for a set of original keycaps, but there are burs from the manufacturing process.

Overall the keyboard is a fond memory for office workers from 1985 up until the new millennium. Membrane keyboards then became the cheaper alternative, and although Model M boards are still being produced by Unicomp, they're using old tooling and are just not quite the same. This keyboard is a part of history, but it still holds its own in many aspects. Is the Model M still relevant in 2021? If you're a typist, you will struggle to find better. If you're in your mid-30s or older, you'll relive your nostalgia. If you're due a zombie apocalypse, you have a weapon. Is it still relevant? Yes—unless you're a pro gamer of course. **–DAVE ALCOCK**

VERDICT
8

IBM Model M

+ **CLASSIC BRILLIANCE** Buckling spring switches; built like a tank; changed the layout of modern keyboards; great typing experience; removable cable.

− **RESIGNED TO HISTORY** 2NKRO; beige; no windows key.

$100 - $300, Second-hand market

SPECIFICATIONS

Form Factor	Full size
Switch Type	Buckling spring
Switch Durability	25-100 million
Media Keys	N/A
Connection Standard	Detachable PS2
Battery Life	N/A
Weight	4.5 - 5.5lb (depending on year/model)
Dimensions	5.55 x 14.25 x 1.45 inches

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Katar Pro XT

They say good things happen in threes

CORSAIR IS ONE of the biggest players in the peripheral game, and it has some iconic mice in its lineup, such as the M65 and the Scimitar. The Katar is also carving itself a place in the range, and in the hearts of its users. It may not have as many buttons or as many novelties as other Corsair mice, but that is part of the charm. It's just a straight-shooting, simple mouse that a lot of FPS/MOBA users like. Think of the SteelSeries Sensei or the Logitech G203—the Katar is the Corsair flavor of these.

The shape is actually very similar to the Logitech G203. It's great for claw-grip users. Fingertip users will also be happy with it—although the sides do look flat, they are in fact angled, so you can get a good grip for those crazy 360 no-scopes the cool kids can do nowadays. The shape isn't as good for palm users, but it is passable—the pointed rear and egg-like back just make it slightly less comfortable compared to other mice in the range. This isn't particularly a bad thing: mice that try to be Jack-of-all-grips tend to be masters of none. The Katar Pro XT ticks the boxes for claw and fingertip grips, which is a win in our book.

There is already a Katar Pro wireless and Katar Pro Ultra-Light, but the new Katar Pro XT has a lightweight paracord cable, rather than the unsleeved cable of the Ultra-Light. It has also put on a few pounds, from 0.152lb to 0.16lb—a difference of around 0.008lb, which is likely the weight difference between the PMW3327 found in the Ultra-Light and the superior PMW3391 that is included in the Pro XT. The PWM 3391 is a fantastic sensor, based on the PMW3389, which is one of the best sensors on the market, if you want pin-point accuracy and excellent control. You can also change the CPI in increments of one, which is just the icing on the cake. There is no excuse for not having your mouse set up exactly how you want it with this sensor.

SPEEDY CLICKS

The Katar Pro XT also brings Quickstrike buttons to the LMB and RMB. These essentially take the gap away from the button and the Omron switches, so the buttons are more sensitive and have less travel before the switches actuate. We didn't think this would make much of a difference, but when trying them next to a Glaive it does feel that they take less effort to press down. Whether this makes a huge difference in-game is another matter. Although there is less bounce to the switch, and it does certainly feel better, we're doubtful whether it will translate to a noticeable difference in terms of getting kills, at least to casual gamers. With professionals, where every millisecond counts, they might be able to differentiate between them better. Although the main buttons feel crisp, the thumb buttons do have a slightly spongy feel to them, and some pre-travel. This might just be due to the main buttons being so crisp, however, and it isn't a big issue at all.

When we received the Katar Pro XT, we didn't know if this third iteration would be needed or not, since there are already two similarly shaped mice on the market. However, after using it for a while, we can safely say it is our favorite of the three. It isn't as lightweight as the Ultra-Light, but the upgraded sensor and sleeved cable make the difference unnoticeable. It is far lighter than the Katar Pro Wireless, and with a simple gaming mouse we prefer not to have to worry about charging the batteries. The sleeved cable drags less than a standard cable, so it almost feels wireless anyway. If you're a claw or fingertip gripper looking for a new mouse, it is certainly one to look at. **–DAVE ALCOCK**

VERDICT
8

Katar Pro XT

⊞ **GOING PRO** Lightweight; incredible control over CPI; LMB and RMB feel great; comprehensive iCUE software support.

⊟ **JUST NO** Thumb buttons feel spongy/less defined; not very suitable for palm grip.

$29.99, www.corsair.com

SPECIFICATIONS

Sensor	PMW 3391 Optical
Max Sensitivity	18,000 CPI
IPS	400
Acceleration	50 G
Programmable Buttons	6
Connection Standard	USB 2.0 Type-A 6ft
Battery Life	N/A
Weight	0.16 lb

Noblechairs ICON Series Black Edition

The right throne for your setup?

© NOBLECHAIRS

WHEN YOU THINK about it, how much of your day is spent sitting on a chair? We aren't ones to judge, but if you are an office worker/working from home that's at least seven hours a day. Also, a lot of us like to kick back at our desks to procrastinate and game after work, enjoying that tiny bit of escapism till the early hours. So if you do the rough math, that's a heck of a lot of time spent in one position. The comfier you are, the longer you will be able to work/game. So why would you not treat your body to the ergonomic tech it needs?

Noblechairs is a premium company when it comes to gaming chairs, stating that, "inspired by the most exclusive cars in the world, Noblechairs combines the latest ergonomics and sports-inspired design for the demanding individual." So, does it meet these lofty promises with its ICON Series Black Edition gaming chair?

Straight out the box, you get a sense that everything is very durable, due to the weight of all the parts. Now that's exactly what you'd expect, especially from a chair setting you back $490. You need to find sprinkles of premium at every corner, and thankfully you get this straight away. The five-star base of the chair is extremely sturdy and made of aluminum, with a lot of weight to it, spreading over a large surface area for better balance—exactly the factors you would look for in a chair's foundation. The parts are all separated evenly, with protection all around, and you are greeted by a large, easy-to-follow manual. It's very visual, so setting up this chair is a breeze. Everything you need comes in the box, including tools, with one spare bolt and screw for safe measure—unless we've made a mistake somewhere!

The Black Edition really is an update to Noblechairs' existing lineup of the EPIC, HERO, and ICON series chairs. The black color just works for every scenario—it's suitable for both domestic or office usage due to the professional, sleek look.

Material choice is very important when it comes to chairs at this price range. For the Black Edition, the chair is covered in German-made vinyl/PU hybrid leather that is super-soft to the touch—it's vegan too. The material's surface is covered in micro-fine pores, which ensures maximum airflow. Paired with the open-pore cold foam used to pad the chair, it delivers excellent breathability. This is great to stop you from getting hot and sweaty, keeping you comfortable for longer. It's also designed for durability, boasting tear and abrasion resistance. These are the kinds of materials being used in high-end cars—fancy.

FIT FOR ROYALTY

Functionality is very prominent in this chair too. It features tons of adjustments to get it to the exact position you need. Everything on this chair is left up to you, giving the consumer full control. Underneath the seat is a blockable tilting mechanism, to get into a comfortable leaned-back position—ideal for watching a movie. The chair has a 90-135 degree inclination angle-adjustment for that perfect positioning. It comes with two detachable cushions, one for lumbar support and one for the headrest, both of which are extremely plush and velvety. The ICON series also features soft-touch 4D armrests, providing four-way directional adjustment. You really get the sense that Noblechairs has thought about every aspect of the chair to give you that premium experience. The rocking mechanism is a cool metal handle, and even the caster wheels are quiet and designed specifically for hard and soft flooring—during our testing the chair was very quiet, creating no distraction.

Piece all of this together and you have a durable, premium, and very well-built addition to any desk. The chair is also very minimal and stealth-like with its understated matte design. What would all this matter, though, if the chair was not nice to sit in for long? Thankfully it's far from uncomfortable. It focuses more on the supportive side, which you will benefit from in the long term. Sitting in this all day causes no problems, allowing you to get that extra edge in gaming/work—the last thing you want is your own chair distracting you and driving you away from your desk. Everything here is of very high quality, which is what you expect for the price, but Noblechairs has hit the high standards it promised to deliver, that's for sure. **–SAM LEWIS**

VERDICT
9

Noblechairs ICON Series Black Edition

+ MEETING HIGH EXPECTATIONS Brilliant build quality; plenty of adjustment; sumptuous comfort.

− PRICEY THRONE Expensive; all-black looks are subjective.

$489.99, www.noblechairs.com

SPECIFICATIONS

Frame	Steel
Material	Vinyl/PU hybrid leather
Dimensions	20.5 x 49.8-53.7 x 22.4" (W x H x D)
Seat height	18.3 - 22.2"
Adjustment	Blockable tilting, height adjustment, 90-135 degree inclination, 4D armrests
Maximum load	330 lbs approx
Weight	61.7 lbs

Netgear Nighthawk XR1000

Excellent wireless, but we demand more ports

WE'RE NOT SURE if Netgear uses Vantablack to coat its Nighthawk routers, but we can report that a DSLR's autofocus has trouble locking onto one. The surface is matte, and drinks light in so effectively that a few red grilles have been added to aid customers in actually seeing the unit they've paid all those dollars for.

The big news with this Nighthawk model is the Wi-Fi 6 (the friendly name for 802.11ax), which tops out at a theoretical 4.8Gbps if you're using a 4x4 client card that can use the 160MHz band. That's pretty good, though in practice you'll only get near it with a very recent PCIe card. A recent MacBook Pro, iPad Pro, or PlayStation 5, or the more common 2x2 cards, can still potentially transfer data at gigabit speeds over the airwaves, though we found that it tends to go in bursts of speed and drops down to around 1Mbps in between.

Despite all this Wi-Fi tech, there's a fairly standard arrangement of ports at the back of the XR1000. Four gigabit LAN ports, one WAN connection, one USB 3.0, and the four ports for aerials join the on/off switch, power coupling, and reset button. We're starting to expect better than this—support for multi-gig fibre broadband, perhaps, with 2.5Gb LAN ports, or at least the aggregation of two Ethernet sockets into a faster one, as seen on Netgear's own RAX80. Of course, if you've got a load of modern wireless devices, you're much less likely to be using an extensive Ethernet network, but we look sadly at our networked storage with its rock-solid wired connection and lament the ways of the future.

Inside the XR1000 there's a triple-core processor with 512MB of RAM and 256MB of flash storage. It runs DumaOS 3, a rather flashy OS if you're used to the austere black-and-white functionality of other routers. Here there's color, and charts, and add-ons called Rapps! And you have to pay $60 a year for security!

What's that? Yes, Netgear Armor is included with this router, but only for a month. After that you need to pay a subscription to continue with its services—which are comprehensive—or live without them. We're used to thinking of security as good and its absence as bad, but baulk at paying a subscription on top of a router that's the same price as a CPU upgrade. The presence of WPA3 means your wireless networks are secure, at least.

But back to the OS. While we found it a little sluggish in operation, with plenty of screen time for the "please wait" message, there's no denying that it's a step forward for routers to have this level of graphical presentation, especially on the map view that ranks gaming servers by location and ping.

GAMING NEEDS

Everything about the XR1000 is designed to move gaming data around swiftly and wirelessly, and at this it largely succeeds, but it is always reliant on the other links in the chain performing at their best too. Putting the XR1000 at the heart of a modest home network in a suburban house, with a mixture of wired and wireless connections, we had no complaints about range or availability. Copying large amounts of data showed up a weakness in the wireless connection compared to wired, but that was in stability, not speed—exactly what we would have expected, and not something we noticed while streaming or gaming.

Sure, we'd have liked more ports, and faster ones too, but wires are not what this router is about, and it makes for a fantastic upgrade over older wireless technology. If you're equipped with the latest Wi-Fi 6 technology, then you can expect improved transfer speeds over Wi-Fi 5, the additional bandwidth helping on a congested home network too. And if low ping is important, the XR1000 has the technology to cherry-pick servers to bring it down. – **IAN EVENDEN**

VERDICT **8**

Netgear Nighthawk XR1000

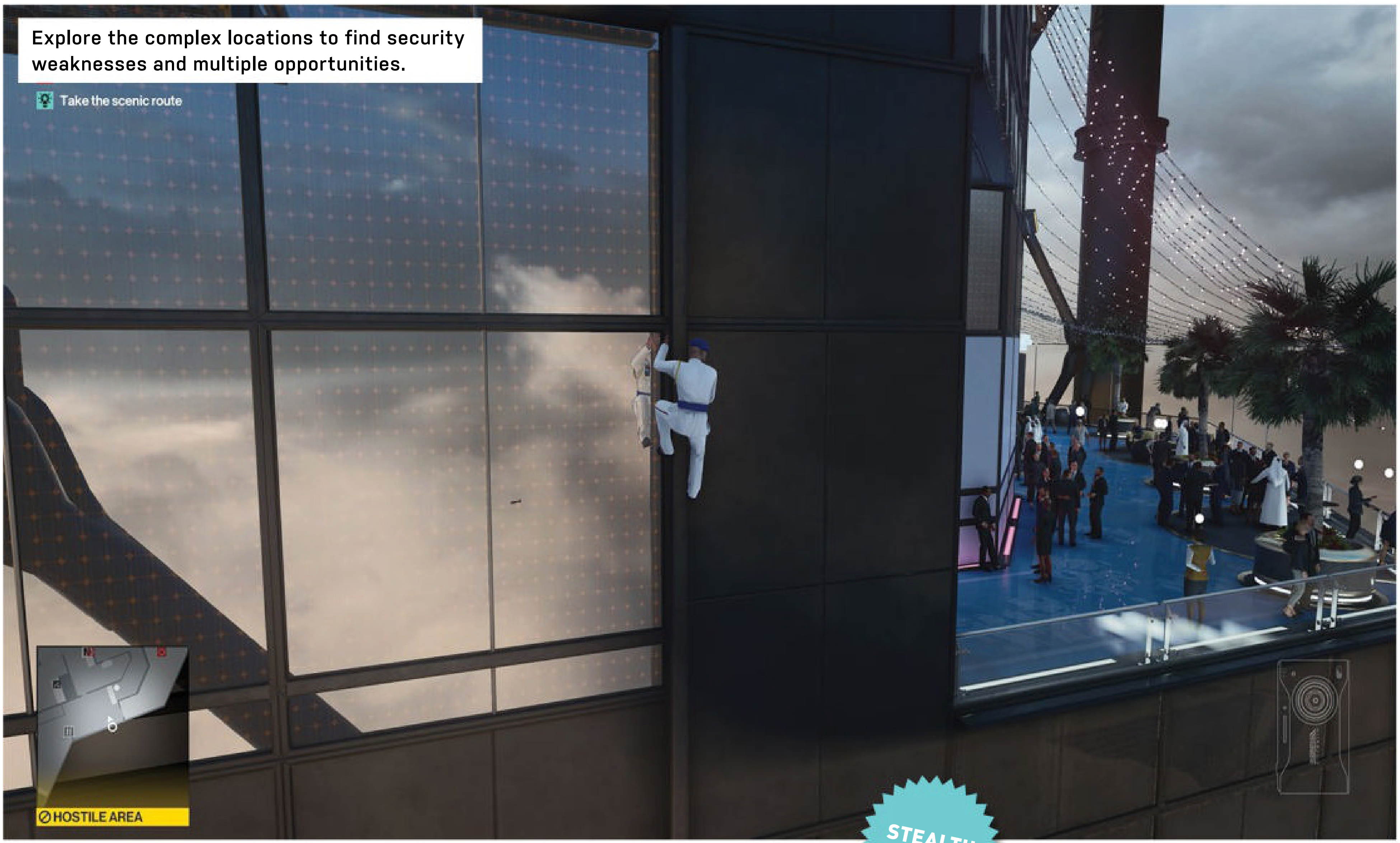
⊞ **SPEEDY** Good wireless speeds; nice graphical OS; great for home use.

⊟ **NEEDY** Restricted to gigabit Ethernet; only one USB port; OS can feel sluggish.

$349.99, netgear.com

SPECIFICATIONS

Wireless	Wi-Fi 6, dual-band, up to 4.8Gbps
CPU	Tri-core, 1.5GHz
RAM	512MB
Storage	256MB
Ports	1x WAN, 4x LAN (all gigabit) 1x USB 3



Explore the complex locations to find security weaknesses and multiple opportunities.

© IO INTERACTIVE

STEALTH GAME

Hitman 3

The trilogy comes to an end, pushed into a grape press

WHAT A WAY to release a game. Spread across five years, two retail models (an initial episodic structure was abandoned in favor of the usual game/DLC model), multiple digital storefronts (*Hitman 3* is a timed Epic exclusive), four continents, and who knows how many murders, we've finally reached the end of the road for the *World of Assassination* trilogy.

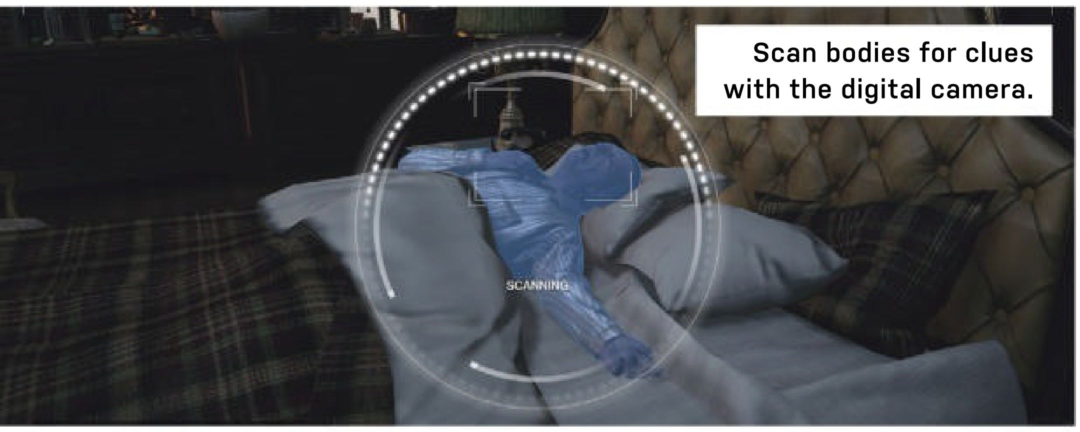
And what a way to finish. *Hitman 3* arrives just as the new consoles are getting settled in, and brings graphical improvements over the previous games with IO's new Glacier engine. If you own the previous two games, the levels will be ported into the new engine, turning it into one huge game with a load of remastered content and six new locations to murderously explore, with the promise of more DLC to come. Buy all three at once, and it'll keep you busy for the rest of the year.

That's because *Hitman* is ridiculously difficult to master. Rather than being the game it outwardly appears—an overarching plot takes Agent 47 across the world, taking out major players in some sort of conspiracy—you can safely ignore all that. Like *Assassin's Creed*, it's there if you need it, but the backstory brings nothing to the actual game. You can even play the missions out of order, a simple spoiler warning standing between you and jumping ahead. Each level has multiple methods of completion—and we mean multiple, not just three or four—with scores and grades awarded. There are leaderboards, so you can compete with your friends as to how fast you can finish levels under certain conditions, such as not being seen. Whole communities exist that are dedicated to speedrunning the levels, where shaving a tenth of a second off the kill time counts as a major result.

And then there are the rest of us, content to wander the halls and warehouses and skyscrapers, watching the security guards work and our targets move around, scoping out potential poisonings, drowning opportunities, happy accidents, and even, if it comes to it, shootings and stabbings. There are distractions to plan, windows of opportunity to prize open, vital supports to loosen, and disguises to liberate from their previous owners. Yet absolutely nowhere can you shake the certain feeling that nothing you're doing has not been foreseen by the devs at IO, their approval of your methods implicit in the stylishness and cleanliness of the resultant kill. Try to line up a shot with a sniper rifle hidden in a briefcase while dancing the tango with a young lady you've plucked from the crowd of NPCs that every level holds, and you will get a custom animation. This was all anticipated. Somewhere in Sweden, there's a smile and a nod.

PLAY WITH MURDER

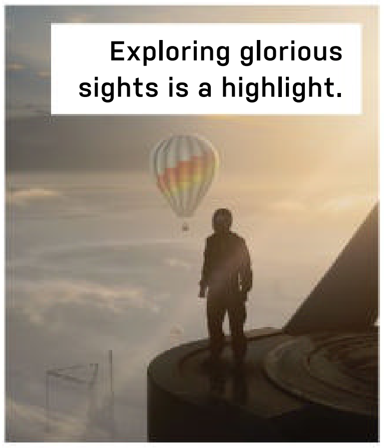
Somewhere in Dubai, meanwhile, you and an AI accomplice are skydiving onto the top of the world's tallest building. The opener isn't a standout level, but with multiple floors, two targets, and crowds of bystanders, it's a good way to ease yourself back in to the *Hitman* mindset if you don't fancy playing the tutorials again. Level two is much better, a hit on



Scan bodies for clues with the digital camera.

Live out your secret dreams of assassination.

Use a range of weapons to take down targets.



Exploring glorious sights is a highlight.

Locations are varied and interesting, each with a unique mood and flavor.

someone to do with the backstory set in a bleak manor house on an English moor. It quickly becomes a locked-room mystery reminiscent of *Knives Out*, as Agent 47 takes the place of a private investigator. He is given (almost) free rein inside the mansion to explore and interrogate, as he looks into the supposed suicide of a resident, slipping along secret passageways, contemplating the deadly possibilities of falling chandeliers, and using his knowledge of poisons to calculate an accurate time of death. He does not attempt Daniel Craig's remarkable accent, however, and for this we are forever grateful.

Later, in Berlin, 47 infiltrates a full-on EDM rave searching for not one but 10 targets, some of whom are disguised and have plenty of bodyguards. This level is probably IO's masterpiece, as the wheels within wheels turn, your mental map forms, and holes appear in the tightest security. A level set in Chongqing, China, is all flashing signs and noodle bars masking a modern underground facility filled with guards, mind-control devices, and the kind of air vents Adam Jensen would kill for.

Mission Stories and Escalations return, but are toned down compared to earlier installments, with just a handful per level or, in some cases, none at all. Agent 47 retains his psychic ability to see targets and guards through walls, also identifying those who will see through his disguise. A slightly baffling addition is a digital camera, capable of scanning electronic locks ready for hacking, and dead bodies to provide clues about the cause of death. It even takes pictures, but isn't a replacement for a proper photo mode, which *Hitman* sadly lacks. Its addition is fine, but it's not something *Hitman* was crying out for. Other tweaks, such as much harder Escalations, and a Sniper Assassin mode that actually focuses on sniping, are evidence of IO trying to hone the modes into their best possible form. Ghost Mode, the series' toe-dip into the world of multiplayer, has left the building.

The only thing *Hitman* needs, really, is a protagonist who's not carved out of a lump of ice. Yes, he's meant to be cold and calculating, a cipher for us to imbue with our dreams of secret murder (and, at the moment, of international travel—a tourist mode would be welcome), but a sliver of humanity wouldn't go amiss.

We're certain that this isn't the end of *Hitman* (the closing cutscene sets up another game, but excitingly, IO is tackling the James Bond franchise next), but *Hitman 3* sees Agent 47 go out with the kind of spectacular bang he probably wouldn't approve of, unless a rubber duck was involved.–**IAN EVENDEN**

VERDICT **9**

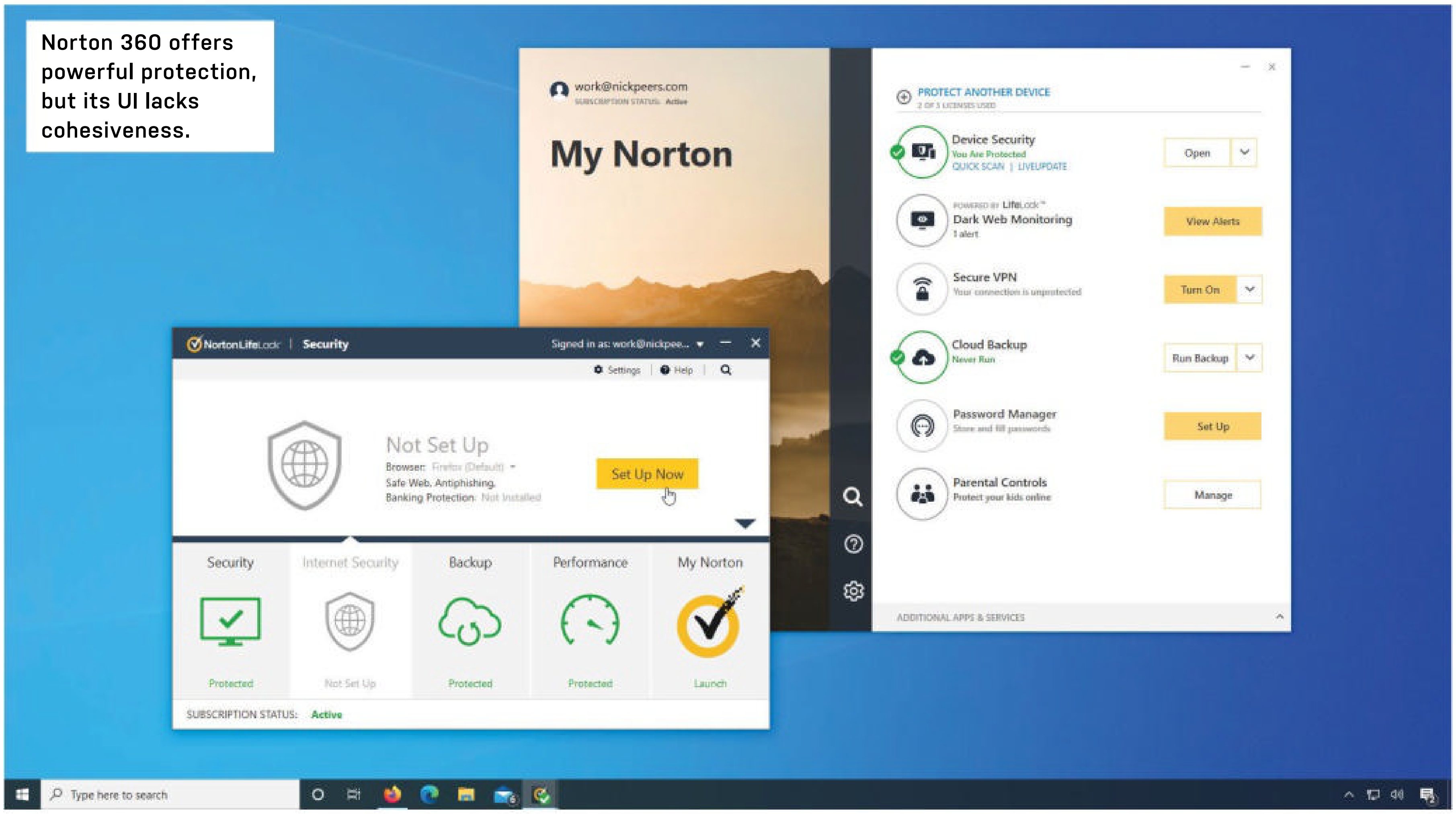
Hitman 3

CREED Stealthy adventures in exotic places; meeting interesting people and killing them.

DREAD Protagonist Agent 47 is a bit, well, lacking in character.

RECOMMENDED SPECS CPU, i7 4790 or equivalent. RAM, 16GB. GPU, GTX 1070 / RX Vega 56

$60, hitman.com, Rated M for Murrrrrder.


work@nickpeers.com
SUBSCRIPTION STATUS: Active
My Norton
PROTECT ANOTHER DEVICE
2 OF 3 LICENSES USED
Device Security
You Are Protected
QUICK SCAN | LIVEUPDATE
Open
POWERED BY LifeLock™
Dark Web Monitoring
1 alert
View Alerts
Secure VPN
Your connection is unprotected
Turn On
Cloud Backup
Never Run
Run Backup
Password Manager
Store and fill passwords
Set Up
Parental Controls
Protect your kids online
Manage
ADDITIONAL APPS & SERVICES
NortonLifeLock | Security
Signed in as: work@nickpee...
Settings
Help
Not Set Up
Browser: Firefox (Default)
Safe Web, Antiphishing,
Banking Protection: Not Installed
Set Up Now
Security
Protected
Internet Security
Not Set Up
Backup
Protected
Performance
Protected
My Norton
Launch
SUBSCRIPTION STATUS: Active
Type here to search

Norton 360 offers powerful protection, but its UI lacks cohesiveness.

© NORTON

Norton vs McAfee

Which of these security titans has the edge in 2021?

ONCE UPON A TIME, this head-to-head would have been billed a clash of the titans. Nowadays, however, both McAfee and Norton find themselves squeezed by an increasingly crowded market. Nevertheless, both continue to hold their own, so for this match-up we've paired their premium products—McAfee Total Protection and Norton 360 Deluxe—against each other. We'll see how their core protection matches up, plus which one delivers the best range of features.

Let's begin where it matters most, with a close look at each product's ability to detect, block, and remove malware in all its forms. As always, you'll find most of what you need with the independent lab reports. Here, the omens are good for both products, with both sweeping the board with top marks from AV-TEST labs. Both also secured the highest triple-A rating from SE Labs, although McAfee came out top here on account of its perfect rating in the false-positive tests (100 percent to Norton's 96 percent). Both products achieved an "approved" certification from AV-Comparatives, but it's here you realize that while both perform superbly, they're no longer best in class (that accolade goes to either Kaspersky or Bitdefender). Only Norton passed the notoriously tricky MRG-Effitas tests with flying colors (McAfee didn't submit itself for evaluation). It translates into both products catching virtually everything the labs threw at them, including zero-day malware attacks.

When it came to system performance, McAfee proved marginally quicker than Norton in key areas, particularly when run on more powerful PCs. This saw it gain its sole award—Silver in Overall Performance—from AV-Comparatives.

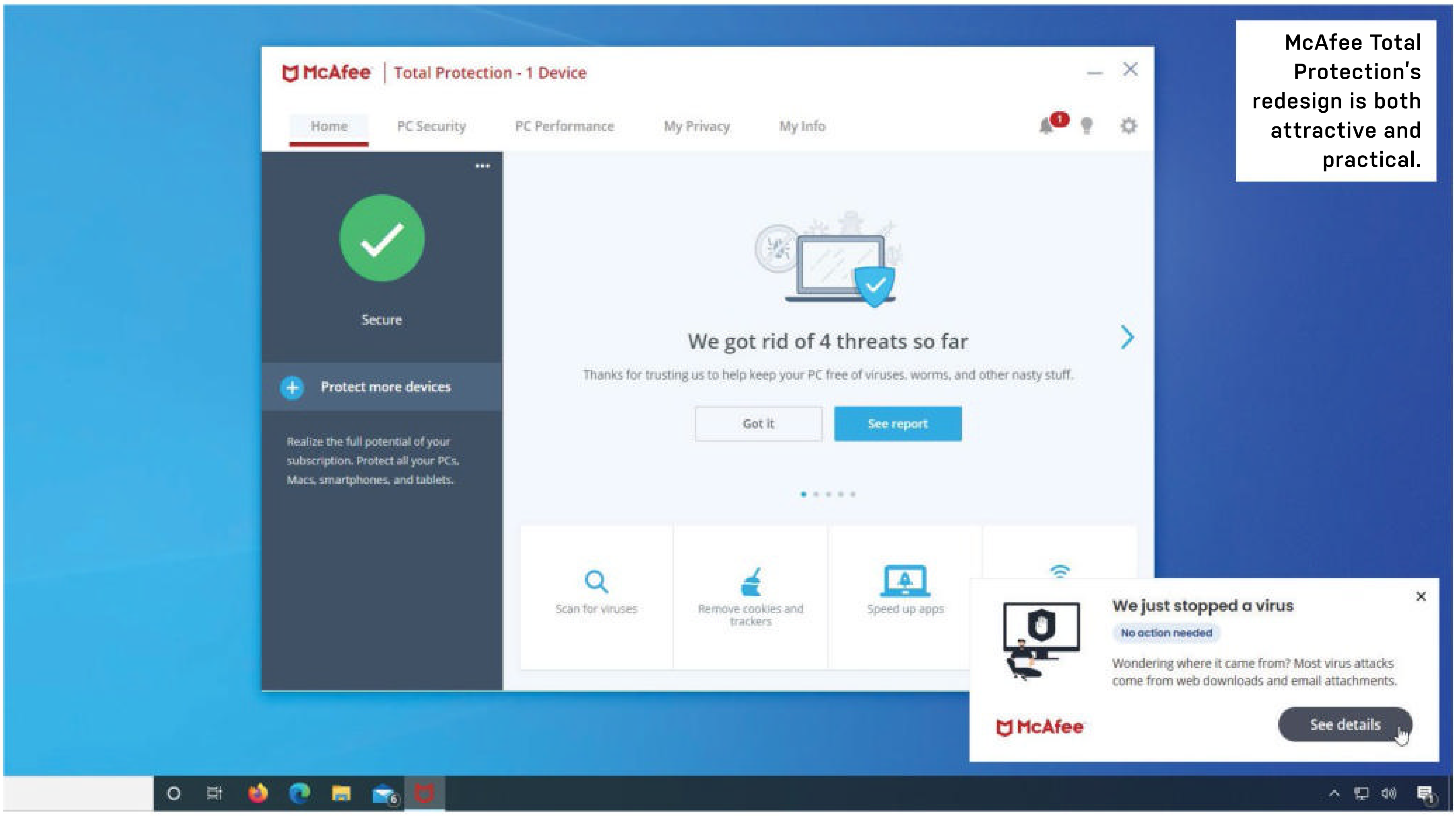
We also put both products through their paces with some real-world malware on an isolated Windows 10 VM running on macOS. Everything we tried was caught with ease, but it gave us an insight into how each product handled threats as they were detected—whether via the real-time protection component or a system scan. Here, McAfee's slick new user interface impressed us more, with its visible notifications reassuring us each time it blocked some malware in its tracks.

Ultimately, both products provide excellent core protection, while McAfee enjoys an edge in the overall performance stakes. So next we took a deep dive into the additional protections offered. Both offer a lot for your money: there's unlimited VPN as standard, along with a password manager and web plugins that scan websites as you load them for potential malicious activity. Both offer parental control tools, although McAfee's Safe Family is only offered with a 10-device subscription. Neither holds a candle to Kaspersky's offering.

The tools then diverge. McAfee offers a handy tool for creating encrypted vaults to store sensitive files in, which enables you to store files in any cloud provider without worrying about hackers getting their hands on them. There's also a file shredder, although it's very basic.

Norton offers Cloud Backup, which lets you store personal files on the company's secure servers for both backup and security purposes. How much you get depends on your flavor of Norton 360—a miserly 50GB with a Deluxe subscription. It's very simple to set up but doesn't make it clear how your data is encrypted, or who holds the encryption keys. Given how ubiquitous cloud storage is these days, we think McAfee's encryption option is more flexible, given you can combine it with existing cloud accounts.

However, Norton does score bonus points for its Dark Web Monitoring tool, which tracks your personal data—including email, bank account, mother's maiden name, and driver license number—and alerts you should any breaches occur. It's also added a School Time component to its parental control to help keep kids focused while learning from home.



Realize the full potential of your subscription. Protect all your PCs, Macs, smartphones, and tablets.

We got rid of 4 threats so far

Thanks for trusting us to help keep your PC free of viruses, worms, and other nasty stuff.

We just stopped a virus

Wondering where it came from? Most virus attacks come from web downloads and email attachments.

McAfee Total Protection's redesign is both attractive and practical.

© MCAFEE

Both apps also differ when it comes to performance optimization options. Norton offers basic disk optimization and file cleanup tools, along with a handy startup manager, while McAfee goes with an app booster that works proactively to hand additional system resources to apps running in the foreground. There's also the McAfee Web Boost extension, which promises to boost Google Chrome's performance by stopping videos from automatically playing.

USABILITY

A security product's user interface is important in guiding the user to setting both appropriate levels of protection and helping them deal with a malware attack. McAfee's 2021 product line catches the eye for all the right reasons thanks to a slick, modern new UI. Crucially, it's more than just eye candy, having been streamlined, reorganized, and made simpler to navigate. That's evident from the moment you first install the product. The app provides plenty of steering, and its alerts are large, prominent, and reassuring when they do pop up. The main window is a textbook example in restraint. All four sections—PC Security, PC Performance, My Privacy, and My Info—comprise a headline carousel of key recommendations, beneath which are a handpicked selection of icons highlighting the suite's key features.

If you're worried that McAfee is skimping on protection, click the settings button in the top right corner to reveal additional options for each component missing from the main interface, from firewall and vulnerability scanner to anti-spam tool.

At first glance, Norton 360 seems to be following similar lines, but dig deeper and you'll realize it's a clumsy amalgamation of two principal UIs. Front and center is the My Norton view, which is a slick, well-designed portal providing a quick summary of—and shortcuts to—the available protections, with a handy search tool that puts the entire suite at your fingertips.

At this point we encountered our first major irritation: despite already being activated, we were forced to log in to our Norton account again within the program to unlock several components. That's bad enough without having to jump through several CAPTCHA challenges. We then discovered our second disappointment: Norton's underlying protection still uses the "classic" interface, which is where most of your configuration time will be spent. It splits Norton 360's major components into four sections, but the somewhat dated user interface, pop-up notifications and warnings feel less intuitive and harder to navigate than McAfee's offering.

Ultimately, you'll be putting your PC's security in safe hands with either product, with Norton just edging things, but not enough in our view to sway things decisively in either app's favor (if locking down your PC as tight as possible is your sole motivation, look at Bitdefender or Kaspersky). It comes down to what additional protections you want. Norton's Dark Web Monitoring tool is a winner, but we think an encrypted file vault is more valuable than another cloud backup add-on, which tilts the pendulum back toward McAfee.

What settles things for us is McAfee's reduced demands on your system, along with its redesigned interface. McAfee Total Protection has been laid out logically to put you within easy reach of all the tools, while providing useful hints and tips. Its notifications and warnings are also more visible, which could be crucial if you find yourself under attack. **–NICK PEERS**

VERDICT
8

McAfee Total Protection 2021

+ **PURE GOLD** fast and responsive; slick but navigable UI; file encryption.

− **FOOL'S GOLD** core protection not best in class; lackluster parental controls.

RECOMMENDED SPECS 1GHz processor, 2GB RAM, 500MB free hard drive space, Windows 10.

$119.99/year for 10 devices, mcafee.com

VERDICT
7

Norton 360

+ **KING OF THE HILL** Rock-solid protection; Dark Web Monitoring add-on is good.

− **FOOL ON THE HILL** Anti-malware components look dated; heavy touch on system.

RECOMMENDED SPECS 1GHz processor, 2GB RAM, 300MB free hard drive space, Windows 10.

$104.99/year for 5 devices, us.norton.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON…

> Dream Machine Storage
> Buyer's Remorse
> GeForce vs Quadro

Gaming & Dev Work

Max PC, I intend to build a system for 2 primary purposes, to play the latest AAA games at max settings and to develop AAA games using Blender, GoDot, Gimp, Inkscape, and MakeHuman. What video card would I need for this? The latest Ti or a Quadro or both?

–Chris Williams

EDITOR ZAK STOREY RESPONDS: Hi Chris, well at the time of writing, sourcing any form of card is like trying to find a 7nm transistor in a haystack, and that doesn't look likely to change any time soon. But nonetheless you raise an interesting question.

Realistically there's not a massive difference between a GeForce card and something like a Quadro. Traditionally, what a Quadro or enterprise-styled card would get you was access to way better customer support from Nvidia directly (if you're having problems with its drivers, for example), more memory (which can be a massive boon in certain workloads), a maxed out GPU die (for slightly more computational performance), far better endurance and warranty (albeit at lower clock speeds), and a few other developer features too, used for more compute-heavy tasks such as CAD rendering, AI workloads, and 3D modelling.

Theoretically, a Quadro is better, especially if you pair it with something like an Nvidia Tesla (I recommend doing some research into Nvidia Maximus, and how that works today). But I think the question that has to be asked is: "Is it worth it?" Quadro cards can cost upward of four to five times as much as the top-end equivalent GeForce card, and you're definitely not getting that much more performance from it from a purely fps perspective, unless you're talking about very specific workload demands again.

Most of the contacts and folk I've spoken to in the game-development industry in the last few years actually recommend just going for a "standard" GeForce card these days, as it does pretty much everything you need it to, but at a far lower cost. If it does go wrong, you can just replace it with another and still have a heck of a lot of cash left over.

Additionally, if you're serious about optimization and compatibility, you actually want a breadth of systems and GPUs you can test on, and swap components out with. It's all well and good developing a game on an RTX 3090 and an AMD Ryzen 9 5950X, but that's such a small segment of your potential market. Just taking a quick look at Steam's Hardware Survey stats, the top five graphics cards used (accounting for 28.79 percent of all users) are, in order, the Nvidia GTX 1060, 1050 Ti, 1650, 1050, and RTX 2060—none of which are flagship products. In fact the RTX 3090 only accounts for 0.22 percent of all users who've taken the survey, and the 2080 Ti accounts for 0.77 percent. Perhaps even more surprisingly given Ryzen's prominence, on the CPU side of things, 43 percent of users are still using quad-core processors without Hyper-Threading. It's worth checking out https://store.steampowered.com/hwsurvey

Long-term Build?

Maybe this is more of a seed for an article idea? The PC world is changing fast, PCIe 4.0, New era of graphics cards, SSDs faster and larger, AMD and Intel running neck and neck… is 2021 going to be a year where I can build a long term rig, without buyers remorse?

What are the parts I want to place around my new 3080 card I have been drooling over? Will this one card run 2x 4k UHD monitors at 60hz? (what about 3?)

Agree that the methods to subscribe suck. I want your mag, I'll seek it out. Even if it means jumping through a couple hoops. **–Shawn C**

EDITOR ZAK STOREY RESPONDS: Honestly Shawn, I totally understand where you're coming from. It's one of these things. There's a saying in the car industry, that when a buyer turns the wheel for the first time in their new car on the forecourt, the total value of the vehicle drops by 25 percent immediately.

I honestly believe it's worse in the computing industry, especially given how competitive it is year on year. We're still seeing massive advancements from a performance perspective, and resale value on second-hard parts is often terrible outside of official vendors and refurbs.

↘ submit your questions to: comments@maximumpc.com

But on the whole, yeah I think perhaps now is actually a fairly good time to buy a long-term rig (once stock's more readily available again). It's always difficult to predict what the future might bring, but generally speaking I'm not expecting there to be much upset outside of predictable performance bumps. The Ryzen 5000-series processors are impeccable, DDR4 is super-nippy, storage is exceptional, alongside cooling and cases, and on the whole graphics cards are fairly solid solutions too, especially if you're on 1440p or lower. That's not to say you'll be able to play the latest AAA games for the next 10 years at 4K 60fps no sweat, but now's a better time than ever. I'd recommend a minimum of 32GB of DDR4 @ 3,733MHz, a 12-core, 24-thread processor, and one of the newer PCIe 4.0 drives (either the Samsung 980 Pro, or anything with the Phison E18 controller, such as the Corsair MP600 Pro, or the Sabrent Rocket 4.0 Plus). Use something like this as your base https://pcpartpicker.com/list/kdHy3Z

Buyer's remorse is again likely to fall on how you view things. No matter what happens, there's always going to be a better model out there within a year or two at most—it's inevitable. As long as you don't look at it as a financial investment, then generally speaking you should be fine.

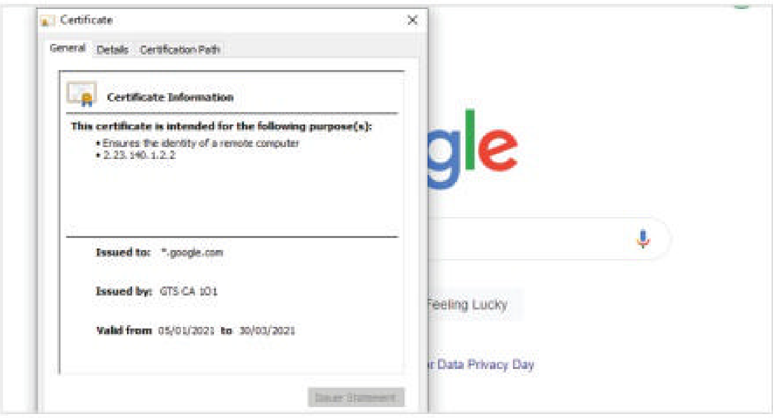
Dream NAS?

Hi Zak, thank you kindly for your efforts to solve my subscription problem. It was greatly appreciated. I can't believe it was so difficult to do a simple 2-year renewal of my subscription.

I was sad to hear that you and your fiancee both got COVID-19. I hope your recovery goes well. I saw an X-ray of the difference between a smoker's lungs and COVID-19 lungs, and the latter looked way worse.

[NOW ONLINE]

WHAT IS AN SSL CERTIFICATE?



Certificate

General Details Certification Path

Certificate Information

This certificate is intended for the following purpose(s):

- Ensures the identity of a remote computer
- 2.23.140.1.2.2

Issued to: *.google.com

Issued by: GTS CA 1O1

Valid from 05/01/2021 to 30/03/2021

Secure Sockets Layer, commonly referred to as SSL, is a security standard for encrypting the communication between a web server and the client's web browser. Although the term is still used in common parlance, the SSL protocol has in fact been replaced with the TLS protocol, which stands for Transport Layer Security. Read the full article here: http://bit.ly/SSLCertMPC

In the February issue, you muse about the next Dream Machine, and whether to do NAS. I have a NAS setup consisting of four Seagate IronWolf drives at 12TB each, that are mirrored and striped to 24TB. I figure that will hold me until I die. I've put all my CDs, DVDs, and BluRays on it, and that only reached 6TB.

Here's what might interest you. How about two Corsair MP400 at 8TB each, striped to a total of 16TB, and then add a single Seagate IronWolf Pro drive at 16TB for daily backup. I just priced this at www.Newegg.com, and the total was $3,150 (although they didn't have the MP400's in stock). Just imagine the speed of striped SSDs.

Anyway, I loved the issue, especially the retail versus street prices of the Mirror Maze system. **–David**

EDITOR ZAK STOREY RESPONDS: Thanks for the kind words David, always much appreciated, and glad to hear that your subscription problems have been resolved (for anyone else having trouble, ping me an email at zak.storey@futurenet.com).

Yeah COVID certainly wasn't a fun experience, my other half works as a receptionist in a medical surgery so she sadly caught it there, as there was an outbreak. Fortunately we're both quite young, and the side effects were far less severe for us. In fact I was almost entirely asymptomatic. I didn't have a cough, or loss of taste or smell, or a fever at all. I had a bit of tiredness, back pain, muscle aches, and writer's block/brain fog (really not helpful when you work as an editor) for about two weeks during my self-isolation.

Bizarrely I also had really bad motion-sickness for close to two months afterwards as well. Even when I was driving, I just felt like the world was spinning and I was going to vomit, it was very odd.

But genuinely it was quite terrifying. I've got a lot of elderly family members and grandparents, some of whom are going through chemotherapy, and so just the notion that I could've infected them without even knowing I had it, if it wasn't for that positive test, is just terrifying to me. It's part of what makes it such a problem to deal with—just the breadth of symptoms, and how much they vary depending on so many different factors.

As for a NAS, however, that genuinely sounds like a pretty cool idea, with perhaps a few slight tweaks. I may aim to try and get four of the drives and then find a solution to run them in RAID 10, so we've got both striped and backed-up data across the four. My worry, however, is the bottlenecks that might come with that. It's been a long time since I've tried setting up RAID, but I remember testing SSD RAID way back in 2016, when I first joined *Maximum PC* in fact, and finding that although the sequential performance improved quite dramatically, actual real-world and random 4K performance wasn't anywhere near as strong. At the time I believe this was because of the CPU potentially acting as a bottleneck—obviously things have come a long way since then, but nonetheless it'd be interesting to see just how well that would perform today with PCIe drives.

I'm also slightly concerned about putting QLC drives in a NAS, just because the repeated read and writes on that system could lead to early failures. Endurance-wise it might not be quite as effective as running something with SLC, or TLC NAND flash for that matter.

Bizarrely, PCIe 4.0 drives might actually be the better solution here, as they cost more or less the same now as 3.0 drives, and provide far higher performance. Running in pure RAID 1, (or RAID 10 if you've got the cash), although you shouldn't see higher sequentials (PCIe 4.0 x4 taps out at about 8GB/s, which is what we're currently seeing with the latest Phison E18 drives), you will likely see far higher random 4Ks, which is more useful in real-world scenarios anyway.

Hmmm, it certainly looks like we've got some testing to do.

THE BUILDS

BUDGET

WE'RE STARTING to dread putting these build lists together, especially when it comes to the GPU situation. So let's address that first and foremost. We wrote this piece over a period of 24 hours. Two working days. In that time, the GPU we picked for the AMD build went out of stock overnight, and the GPU we had from last issue for the Intel build skyrocketed in price to a staggering $600. The closest available graphics card, the four-and-a-half-year-old GTX 1050 Ti that's actually in stock, is now $500, and of course only available on Amazon via certain resellers.

We don't know what to tell you. Right now, if you're building these systems, you just have to be on your toes and hope you can pick up a GPU at a reasonable price when it's available. Between the crypto-boom, the miners, the scalpers, and ordinary folk just trying to buy a damn graphics card, the likelihood of actually being able to get one of anything is near impossible. Fortunately both systems here are configured with integrated graphics as standard, so if you desperately need a rig, you can pick one of these up and run it through integrated, much like our feature build this issue.

Aside from that, we've swapped out our power supply in the AMD build for our Corsair pick from this month's main build (as the EVGA BR is now the same price), and plumped up for some slightly better spec memory. On top of that we've swapped back to the Core i3-10100 for the Intel setup (integrated graphics, and slightly more affordable), and managed to pick up this dirt-cheap mobo from Asus, to shave off a bit of price from the last issue.

So technically each build has saved around $80 compared to last issue—theoretically true if you can get that 1050 Ti at $210. Technically we've gone down from a ridiculously overpriced GTX 1660 at $300 (last issue, now $600 of course) to a 1050 Ti at $200. But as neither of the cards are in stock, really the true prices of these builds are $540 for the AMD build, and $564 for the Intel system.

AMD INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W Corsair CV450 80+ Bronze **NEW**	$50
Mobo	ASRock B450M-HDV R4.0 M-ATX	$65
CPU	AMD Athlon 3000G	$100
GPU	MSI GeForce GTX 1050 Ti 4GB Gaming X **NO STOCK**	$210
RAM	16GB (2x8GB) Team T-FORCE Vulcan Z @ 3000 MHz **NEW**	$70
SSD	250GB Samsung 980 Pro M.2 PCIe 4.0 SSD	$90
HDD	1TB Seagate Barracuda 1TB 7200 HDD	$45
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$750**

INTEL INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W EVGA 450 BR 80+ Bronze	$50
Mobo	Asus Prime B460M-A Micro-ATX **NEW**	$100
CPU	Intel Core i3-10100 **NEW**	$110
GPU	MSI GeForce GTX 1050 Ti 4GB Gaming X **NO STOCK**	$210
RAM	16GB (2 x 8GB) ADATA XPG Z1 DDR4 @ 3000 MHz	$74
SSD	500GB Samsung 970 Evo M.2 PCIe 3.0 SSD	$70
HDD	1TB Seagate Barracuda 1TB 7200 HDD	$40
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$774**

OH WE SO WANT TO CHANGE the record at this point, but this is just getting worse, month on month. On the flip-side, we are starting to wonder whether graphics cards might actually be a better investment than cryptocurrency. That RTX 2060 Super we recommended last issue for the Intel build—you know, the card that launched early 2019—has gone up by another $400, making it $1,200. Well at least that was the last known price while it was still in stock. Unbelievable.

Aside from that, we have managed to make a few changes. Interestingly, AMD still has zero stock of its latest chips, so we're relying on the Ryzen 5 3600 as our processor of choice at just shy of $195. Intel, on the other hand, seems to be doing just fine, and we've got a bit of budget room to go for the overclockable Intel Core i7-10700K for $327. It's genuinely frustrating because the latest Ryzen processors are incredible, but there's just no stock.

On top of that we've had to swap the motherboard in the Intel rig. It seems that prices across the segment have gone up by around $20-30, so we've picked up the Z490 Pro4 from ASRock at $170. We've also had to downgrade the AMD memory to a 3,200MHz kit, and even with that drop we're still looking at a price increase of $13. We've also switched out the coolers to two slightly more affordable Cooler Master variants—both 240mm, of course. It's worth pointing out that a lot of these parts are interchangeable across the two builds—the storage, power supplies, and cooling in particular, although we'd recommend staying away from 2,400MHz memory for your Ryzen processors, as always.

That said, despite all the bad and sad news, both rigs have managed to come down in price by $100-200 compared to last issue, in no small part because we've "swapped" from the $650 to $800 GPUs from last issue's mid-range builds, to the much more "affordable" $570 GTX 1660 this issue. Oh please let this end.

AMD INGREDIENTS

PART		PRICE
Case	Lian Li PC011-Dynamic	$160
PSU	550W Corsair RMx (2018) 80+ Gold	$105
Mobo	ASRock X570 Phantom Gaming 4 **NEW**	$145
CPU	AMD Ryzen 5 3600	$195
Cooler	Cooler Master Masterliquid ML240L RGB V2 **NEW**	$84
GPU	Zotac GeForce GTX 1660 Gaming Twin Fan **NO STOCK**	$570
RAM	16GB (2 x 8GB) Corsair Vengeance LPX DDR4 @ 3200 **NEW**	$97
SSD	500GB Sabrent Rocket 4.0 M.2 PCIe 4.0	$90
HDD	1TB Seagate Barracuda 1TB 7200 HDD	$40
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$1,511**

INTEL INGREDIENTS

PART		PRICE
Case	Lian Li PC011-Dynamic	$160
PSU	650W EVGA G5 80+ Gold **NEW**	$100
Mobo	ASRock Z490 Pro4 **NEW**	$170
CPU	Intel Core i7-10700K **NEW**	$327
Cooler	Cooler Master Masterliquid Lite 240 **NEW**	$55
GPU	Zotac GeForce GTX 1660 Gaming Twin Fan **NO STOCK**	$570
RAM	16GB (2 x 8GB) G.Skill Aegis 16GB @ 2400	$65
SSD	500GB WD Black SN750 M.2 PCIe 3.0	$65
HDD	1TB Western Digital Caviar Blue 7200	$45
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$1,582**

TURBO

LET'S START WITH the good news first: both processors have seen fairly substantial price reductions! Huzzah! The Ryzen 7 5800X is down by $90 to a sweet $450 (its actual RRP), and the Core i9-10900K is down to $455 down from $505 last issue, which is $30 lower than its RRP. That's good news, but it does put us in a bit of an odd position, given how close the pricing is on that, because if you want a chip for purely multi-threaded applications, the Core i9-10900K is the more affordable bet (nipping past the 5800X by around five percent in benchmarks). However, if gaming and single-core performance is more your thing then the 5800X is the chip to get, as it outmuscles the 10900K by an impressive 20 percent in those applications (Cinebench R20 being used as our comparison here, so your mileage may vary based on application).

To celebrate those price drops we've opted for better mobos, with slicker design aesthetics and better rear I/O. We've done some maneuvering for the power supplies too, as well as swapping out our PCIe 4.0 drive in the AMD system for Sabrent's Rocket 4.0. That shaves $15 off of last issue's Gigabyte variant, which you can put into your kid's graphics card savings fund—by the time they're ready to go to college, they might even be able to afford their own GPU.

So, the elephant in the room—still no graphics cards in stock at this price point. You could wait on availability for one of these blower-style RTX 2080 Supers, for the low, low price of $1,200, or you could get one of the more amped-up gaming versions for near $1,600. Yeah, don't do either of those things. Sadly, even on the cheapest end that's a price increase of around $150 compared to last issue's refurbished EVGA. But on the plus side you can always run that Core i9-10900K system on integrated graphics, right guys? Right?! (Sorry AMD, you miss out on that luxury.)

Is there an end in sight to all of this? Well, not for now. If you really want to game, game streaming is a more affordable solution. If you need a GPU for anything else, however, your choices are limited.

AMD INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$147
PSU	750W be quiet! Pure Power 11 80+ Gold **NEW**	$80
Mobo	Gigabyte X570 Gaming X ATX **NEW**	$175
CPU	AMD Ryzen 7 5800X	$450
Cooler	Corsair iCUE H150i Elite Capellix 360mm AIO	$190
GPU	Asus GeForce RTX 2080 Super 8GB Strix Gaming **NO STOCK**	$1,200
RAM	32GB (2 x 16GB) Crucial Ballistix DDR4 @ 3600 **NEW**	$159
SSD	1TB Sabrent Rocket 4.0 M.2 PCIe 4.0 **NEW**	$145
HDD	6TB Western Digital Blue	$130
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$2,701**

INTEL INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$147
PSU	750W Seasonic Focus Plus Gold 80+ Gold **NEW**	$130
Mobo	MSI MAG Z490 Tomahawk ATX **NEW**	$200
CPU	Intel Core i9-10900K	$455
Cooler	NZXT Kraken X73 360mm	$180
GPU	Asus GeForce RTX 2080 Super 8GB Strix Gaming **NO STOCK**	$1,200
RAM	32GB (2 x 16GB) Kingston HyperX Fury DDR4 @ 3600 MHz	$160
SSD	1TB Corsair MP400 M.2 PCIe 3.0	$115
HDD	6TB Western Digital Blue HDD	$130
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$2,742**

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